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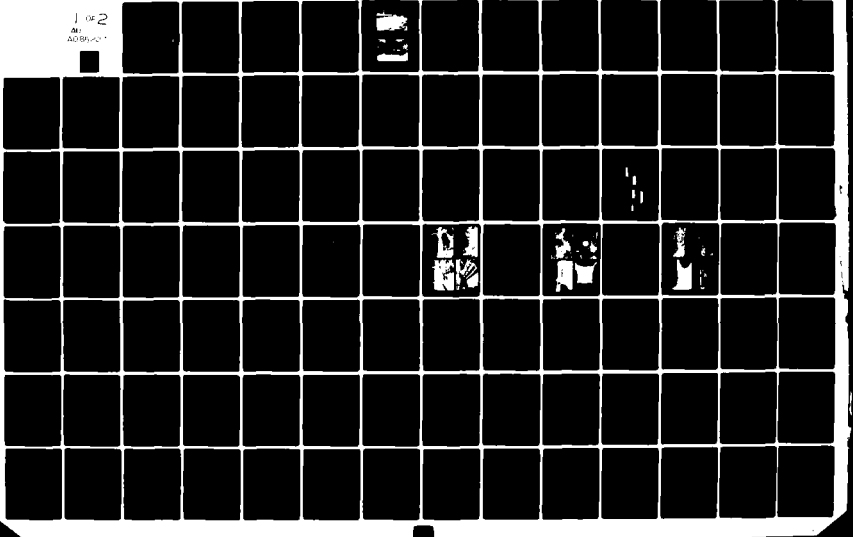

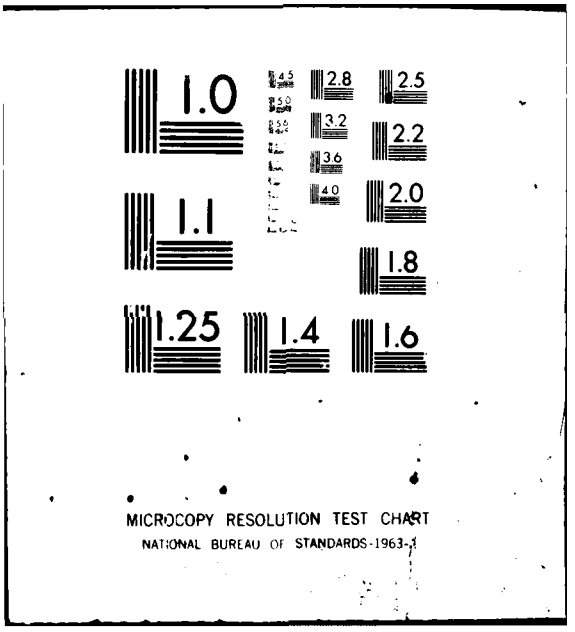
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SUSQUEHANNA RIVER BASIN
WEST BRANCH OF HAMMER CREEK, LEBANON COUNTY

National Dam Inspection Report.
PENNSYLVANIA

LEVEL II

LEBANON RESERVOIR DAM No. 1.

Number

NDI I.D. No. PA-00595,
PENNDER I.D. No. 38-1,

Susquehanna River Basin, West Branch of Hammer Creek, Lebanon County, Pennsylvania.

PHASE I INSPECTION REPORT,
NATIONAL DAM INSPECTION PROGRAM

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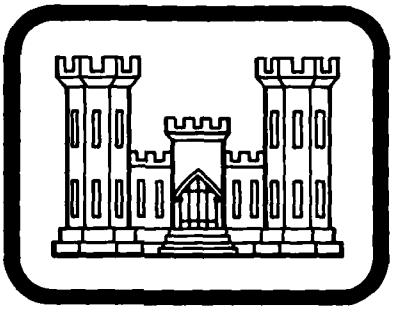

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PREPARED FOR

(15) Patrick M. Mihalcin

DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203
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(11) MARCH 1980

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PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D. C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topograhic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition, and the downstream damage potential.

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

ABSTRACT

Lebanon Reservoir Dam No. 1: NDI I.D. No. PA-00595

Owner:	City of Lebanon
State Located:	Pennsylvania (PennDER I.D. No. 38-1)
County Located:	Lebanon
Stream:	West Branch of Hammer Creek
Inspection Date:	8 November 1979
Inspection Team:	GAI Consultants, Inc. 570 Beatty Road Monroeville, Pennsylvania 15146

The visual inspection, operational history, and hydrologic/hydraulic analysis indicate that the facility is in fair condition.

Deficiencies noted by the inspection team included heavy overgrowth across the embankment crest and slopes, rodent burrows along the downstream embankment face, a deteriorated emergency spillway, and minor seepage beneath the emergency spillway and around the outlet conduit. These deficiencies are, for the most part, attributable to a general lack of adequate maintenance since the facility was phased out of operation in 1973.

The size classification of the facility is small and its hazard classification is considered to be high. In accordance with the recommended guidelines, the Spillway Design Flood (SDF) for the facility ranges between the 1/2 PMF (Probable Maximum Flood) and the PMF. Due to the high potential for damage to downstream structures and loss of life, the SDF is considered to be the PMF. Results of the hydrologic and hydraulic analysis indicate the facility will pass and/or store only 16 percent of the PMF prior to embankment overtopping. A breach analysis indicates that failure under less than 1/2 PMF conditions could lead to increased downstream damage and potential for loss of life. Thus, based on screening criteria provided in the recommended guidelines, the spillway is considered to be seriously inadequate and the facility unsafe, non-emergency.

It is recommended that the owner immediately:

a. Develop a formal emergency warning system to notify downstream residents should hazardous conditions develop. Included in the plan should be provisions for around-the-clock surveillance of the facility during periods of unusually heavy precipitation.

b. Have the facility evaluated by a registered professional engineer experienced in hydrology and hydraulic structures and take remedial measures deemed necessary to make the facility hydraulically adequate and the emergency spillway structurally sound.

c. Clear all excess vegetation from the embankment crest and slopes. In addition, all burrowing animals inhabiting the embankment should be exterminated and their burrows filled.

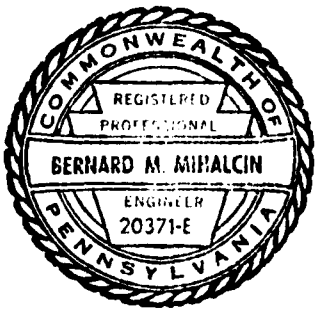
d. Develop formal manuals of operation and maintenance to ensure future proper care of the facility.

e. Specifically address in all future inspections the seepage conditions beneath the emergency spillway and around the outlet conduit at the downstream embankment toe noting changes in turbidity and/or rate of flow.

f. Provide upstream (inlet end) control of flow through the outlet conduit or develop a plan to control flow through the conduit at the inlet end in the event emergency conditions develop in the pipe within the embankment.

GAI Consultants, Inc.

Bernard M. Mihalcin, P.E.



Date 27 March 1980

Approved by:

JAMES W. PECK
Colonel, Corps of Engineers
District Engineer

Date 3 May 1980

DLB:BMM/lc

Downstream Face

Upstream Face

OVERVIEW PHOTOGRAPHS

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PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
LEBANON RESERVOIR DAM NO. 1
NDI# PA-00595, PENNDER# 38-1

SECTION 1
GENERAL INFORMATION

1.0 Authority.

The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.

1.1 Purpose.

The purpose is to determine if the dam constitutes a hazard to human life or property.

1.2 Description of Project.

a. Dam and Appurtenances. Lebanon Reservoir Dam No. 1 is an earth embankment approximately 30 feet high and 700 feet long, including spillways. The facility is provided with separate service and emergency spillways located at the right abutment. The combined spillway crest length is approximately 48 feet. The facility is equipped with a 16-inch diameter cast iron blowoff conduit located about 300 feet to the left of the spillways. The blowoff is controlled by a 16-inch diameter gate valve located at about the middle of the downstream embankment slope. The facility is also equipped with system of water supply conduits that were phased out of operation in the early 1970's.

b. Location. Lebanon Reservoir Dam No. 1 is located on the West Branch of Hammer Creek in South Lebanon Township, Lebanon County, Pennsylvania. The City of Lebanon, Pennsylvania, is located about 6 miles northwest of the facility. The dam, reservoir, and watershed are contained within the Richland and Lebanon, Pennsylvania 7.5 minute U.S.G.S. topographic quadrangles (see Figure 1, Appendix E). The coordinates of the dam are N40° 16.8' and W76° 21.5'.

c. Size Classification. Small (30 feet high; 82 acre-feet storage capacity at top of dam).

d. Hazard Classification. High (see Section 3.1.e).

e. Ownership. City of Lebanon.
400 South 8th Street
Lebanon, Pennsylvania 17042

f. Purpose. Recreation and emergency water supply.

g. Historical Data. Lebanon Reservoir Dam No. 1 was constructed under private contract to supply both domestic and industrial water for the City of Lebanon in 1871. The original facility was designed by H.P.M. Birkinbine of Philadelphia. Dam No. 1 was one of three similar earth structures located on the West Branch of Hammer Creek in South Lebanon Township. Lebanon Reservoir Dam No. 2 still exists and is located several hundred feet upstream of Dam No. 1. Lebanon Reservoir Dam No. 3 was located about 2000 feet upstream on a small creek in an adjacent watershed to the west of Dam No. 2. Discharge from Dam No. 3 was, however, directed into Dam No. 1.

According to information contained in files obtained from PennDER, Dam No. 3 failed as a result of heavy rainfalls that occurred on July 25, 1925. The combination of the failure of Dam No. 3 (which was never restored) and the heavy runoff from its own watershed resulted in the overtopping and subsequent failure of Dam No. 1. Dam No. 2 reportedly incurred damage due to the heavy rainfall, but, was not overtopped and remained essentially intact. Failure of Dam No. 1 resulted in a breach to the left of the gate house measuring 75 feet across the top and 30 to 35 feet along the base which was subsequently repaired. No casualties were reported resulting from this incident.

Following reconstruction, yearly inspection reports by PennDER predecessors indicate a serious seepage condition along the downstream toe. This condition was adequately controlled in 1938 when the downstream slope was flattened and internal drainage was provided.

Lebanon Reservoir Dam No. 1 along with upstream Dam No. 2 were phased out of active operation in 1973. Both facilities are now used for recreation and emergency water supply only.

1.3 Pertinent Data.

a. Drainage Area (square miles).	0.6 (local) 1.2 (total)

b. Discharge at Dam Site.

Discharge Capacity of Outlet Conduit - Discharge curves are not available.

Discharge Capacity of Service Spillway at Maximum Pool = 130 cfs (see Appendix D, Sheet 7).

Discharge Capacity of Emergency Spillway at Maximum Pool = 340 cfs (see Appendix D, Sheet 8).

c. Elevation (feet above mean sea level). The following elevations were obtained from available drawings and through field measurements that were based on the elevation of the service spillway crest or normal pool at 622.5 feet (see Appendix D, Sheet 1).

Top of Dam	626.0 (design). 625.3 (field).
Maximum Design Pool	Not known.
Maximum Pool of Record	Not known.
Normal Pool	622.5
Service Spillway Crest	622.5
Emergency Spillway Crest	623.0
Upstream Inlet Invert	603.0 (estimated zero storage).
Downstream Outlet Invert	594.9
Streambed at Dam Centerline	598.0
Maximum Tailwater	Not known.

d. Reservoir Length (feet).

Top of Dam	600
Normal Pool	450

e. Storage (acre-feet).

Top of Dam	82
Normal Pool	55
Design Surcharge	Not known.

f. Reservoir Surface (acres).

Top of Dam	9
Normal Pool	11
Maximum Design Pool	Not known.

g. Dam.

Type	Earth.

	Length	700 feet (including spillways).
	Height	30 feet (field measured; crest to downstream blowoff invert).
	Top Width	12 feet.
	Upstream Slope	1.5H:1V (field measured; above normal pool). 2H:1V (below normal pool; see Figures 3 and 4).
	Downstream	3H:1V.
	Zoning	Early correspondence indicates the inner half of the embankment was composed of "selected material" while the outer half was composed of "earth and stone." Internal drainage was provided during subsequent reconstruction.
	Impervious Core	None indicated. See above.
	Cutoff	Partial concrete cutoff in former breach area (see Section 2.1.b.1).
	Grout Curtain	None indicated.
h.	Diversion Canal and Regulating Tunnels.	None.
i.	Service Spillway.	
	Type	Uncontrolled, rectangular, concrete chute channel with masonry

		wingwalls and a concrete sill crest.
	Crest Elevation	622.5 feet.
	Crest Length	10.5 feet.
j.	Emergency Spillway.	
	Type	Uncontrolled, rectangular, concrete chute channel with a broad crest.
	Crest Elevation	623.0 feet.
	Crest Length	37.8 feet.
k.	Outlet Conduit.	
	Type	16-inch diameter cast iron blowoff conduit.
	Length	80 feet (estimated).
	Closure and Regulating Facilities	Flow through the outlet conduit can be regulated by a 16-inch diameter gate valve with controls located about midway along the downstream embankment slope to the right (looking downstream) of concrete valve chamber situated at the downstream embankment toe.
	Access	The outlet conduit control mechanism is housed in a curb box accessible by foot along the downstream embankment slope.

SECTION 2
ENGINEERING DATA

2.1 Design.

a. Design Data Availability and Sources. No formal design reports or calculations are available for any aspect of the facility. Several drawings are available from both the owner and the PennDER (see Figures 2 through 4, Appendix E). A historical report contained in PennDER files entitled "Report Upon Dam No. 1 of the Lebanon City Water Works" by the Water Supply Commission of Pennsylvania, dated December 14, 1914, contains useful descriptive information relative to the design and construction of the facility.

b. Design Features.

1. Embankment. Little information is available relative to the physical characteristics of the embankment. Data contained in PennDER files indicates that the inner half of the embankment was to be made up of selected material while the outer half was to be composed of earth and stone. Available drawings indicate the embankment was originally 15 feet wide at the crest with 2H:1V slopes both upstream and downstream (see Figure 3).

In 1925, the dam was overtopped and subsequently breached. The breach, which began at a point 10 to 15 feet left of the gate house, measured about 75 feet long across the crest and 30 to 35 feet long across the base. In addition, the downstream slope was badly eroded for about 100 feet on either side of the breach.

Repairs to the damaged area were initiated immediately. Included was the placement of a concrete cutoff wall, 5 feet high and 18 inches thick, extending below the bottom of the breach and into the material remaining in place at the ends. The breach was refilled with puddle clay placed in 6-inch layers (see Figure 3).

Remedial work was again necessitated in 1938 in an effort to alleviate seepage along the downstream embankment toe. Additional material (including a rock drain) was reportedly added to the downstream slope and crest in accordance with the details shown on Figure 4. Six-inch diameter drains were placed along the toe of the former slope and discharge into a rock-lined ditch at the base of the present slope (see Photograph 10).

2. Appurtenant Structures.

a) Service Spillway. The service spillway is an uncontrolled, rectangular, concrete chute channel with masonry wingwalls located near the right abutment and to the right of the emergency spillway (see Figure 4 and Photographs 1 and 3). The crest consists of a small concrete sill 10.5 feet in length.

b) Emergency Spillway. The emergency spillway is an uncontrolled, rectangular, concrete chute channel located adjacent to the left wingwall of the service spillway near the right abutment (see Figure 4 and Photographs 1 and 2). The structure was constructed in 1925, subsequent to the flood which caused the embankment to overtop and fail. The crest is divided into two bays by a concrete pier that supports the remnants of a footbridge that once spanned both spillways. The effective crest length (minus the concrete pier) measures 37.8 feet.

c) Outlet Conduit. The blowoff conduit is a 16-inch diameter cast iron pipe with inlet located approximately 300 feet to the left of the service spillway (see Figure 3). The conduit discharges at the downstream embankment toe just beyond a concrete valve chamber that houses one of two 16-inch diameter gate valves located along the pipe (see Figures 3 and Photographs 6 and 7). The valve within the chamber is reportedly inoperable; however, control is provided by a second valve situated just upstream which is operated from a curb box located midway along the downstream embankment slope (see Photograph 8).

c. Specific Design Data and Criteria. No formal design reports, calculations, or specific design data are available for any aspect of this facility.

2.2 Construction Records.

No records are available for any phase of the facility's original construction in 1871. Information relative to the 1925 reconstruction and 1938 renovation is limited to brief reports and several photographs by the Water Supply Commission which are contained in PennDER files.

2.3 Operational Records.

No records of daily rainfall or spillway discharge are available. The events leading to the failure of the embankment in 1925 are well documented in PennDER files.

2.4 Other Investigations.

No records of any formal investigations other than periodic state inspection reports are available. The inspection reports are contained in PennDER files.

2.5 Evaluation.

The available data are considered sufficient to make a reasonable Phase I assessment of the facility.

SECTION 3
VISUAL INSPECTION

3.1 Observations.

a. General. The general appearance of the facility suggests that it is in fair condition.

b. Embankment. Based on observations made during the visual inspection, the embankment is considered to be in fair condition. No evidence of seepage through the downstream embankment face or signs of slope distress were observed. The entire embankment, however, is heavily overgrown and lacks adequate maintenance (see Overview Photographs). At least two small rodent burrows were encountered along the downstream embankment face near the chlorination house. The riprap provided across the upstream embankment face is patchy; however, no evidence of significant erosion was observed.

c. Appurtenant Structures.

1. Service Spillway. The service spillway (see Photograph 3) is considered to be in good condition. No evidence of concrete or masonry deterioration was observed.

2. Emergency Spillway. The visual inspection revealed the emergency spillway is in poor condition (see Photographs 1 and 2). The concrete channel floor is severely scaled and cracked. Some slab uplifting and movement is apparent as is minor seepage through cracks and joints in the lower portion of the channel. The lower channel is overgrown with high grass and shrubs which have rooted themselves between the open cracks and joints (see Photographs 3 and 4).

The remnants of a steel supported footbridge span both the service and emergency spillways. Only the steel frame remains while all planking has been removed (see Photographs 2 and 3).

3. Outlet Conduit. The outlet conduit is reportedly functional; however, it was not operated in the presence of the inspection team. The concrete valve chamber located at the downstream embankment toe appears to be in good condition (see Photographs 6 and 7). The steel access doors atop the chamber are unhinged making the structure somewhat hazardous and susceptible to vandalism. The valve housed within the chamber is reportedly inoperable. Flow

through the conduit is controlled by a valve located about midway along the downstream slope and to the right (looking downstream) of the chamber. Operation of the upstream valve is provided through a curb box opening (see Photograph 8). Some minor seepage (≈ 2 gpm) was observed around the conduit at the base of the chamber.

d. Reservoir Area. Lebanon Reservoir Dam No. 1 is situated along the southern edge of a heavily forested, steeply sloped area known as South Mountain. The northern, eastern and western flanks of the reservoir are comprised of gently to moderately sloped farmland (see Figure 1). No evidence of slope distress was observed in the general area surrounding the reservoir.

e. Downstream Channel. Low flows through the service spillway are channeled as indicated by the thin blue line shown on Figure 1. That is, flows are directed into a small farm pond to the right of the embankment prior to joining the natural stream channel near Pennsylvania Route 419 several hundred feet downstream. A diversion channel cut roughly parallel to the embankment, approximately 150 feet downstream of the service spillway crest, diverts large flows from the service spillway into the original stream channel below the outlet conduit (see General Plan-Field Inspection Notes, Appendix A). Emergency spillway and outlet conduit flows are discharged directly into the original stream channel which is depicted on Figure 1 by a dotted line.

Approximately 2700 feet downstream the original stream channel passes within 100 feet of a structure referred to as "Kralls Church" on Figure 1. This structure is now a private residence. A brief discussion with the owner of this residence revealed that his home experiences some high water almost annually. Due to the close proximity of this home to the stream, along with several other homes and farms further downstream, the hazard classification for this facility is considered to be high as an embankment failure could affect more than a few lives.

3.2 Evaluation.

Based on visual observations, the overall condition of the facility is considered to be fair. Heavy overgrowth and a deteriorated emergency spillway are primarily the result of inadequate maintenance. Seepage observed beneath the spillway and around the outlet conduit are considered minor at this time, but should continue to be assessed in future inspections.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Normal Operating Procedure.

The reservoir is presently used for recreation and emergency water supply only. It is not a regular part of the City of Lebanon's water supply system. The facility is essentially self-regulating. Excess inflows discharge through the spillways and are directed downstream. The outlet conduit and supply system are reportedly functional; however, no specific operating procedures exist and no formal operations manual is available.

4.2 Maintenance of Dam.

The facility has been virtually without maintenance since it was phased out of operation in 1973. The owner is capable of performing emergency maintenance if needed. No formal maintenance manual outlining any maintenance procedures is available.

4.3 Maintenance of Operating Facilities.

See Section 4.2 above.

4.4 Warning System.

No formal warning system is in effect.

4.5 Evaluation.

Since 1973, the facility has existed virtually without any maintenance, routine or otherwise. Both the outlet conduit and water supply system are reportedly functional; however, neither were operated in the presence of the inspection team. Formal operations and maintenance manuals need to be developed and a formal warning system put in effect.

SECTION 5
HYDROLOGIC/HYDRAULIC EVALUATION

5.1 Design Data.

No formal design reports, calculations, or design data are available for any aspect of this facility.

5.2 Experience Data.

No formal records of daily rainfall and/or spillway discharge are available for this facility. The embankment failure in 1925 is well documented in PennDER files; however, no relative hydrologic or hydraulic data is available. The present emergency spillway was constructed as a result of that event.

5.3 Visual Observations.

On the date of inspection, no conditions were observed that would indicate the spillways could not perform satisfactorily during a flood event, within the limits of their design capacities. The lower portion of the emergency spillway discharge channel is deteriorated, characterized by severe concrete scaling, extensive cracking and some slab uplifting. Continued lack of maintenance increases the possibility that high flows could further damage the deteriorating spillway structure and possibly endanger the embankment.

5.4 Method of Analysis.

The facility has been analyzed in accordance with the procedures and guidelines established by the U. S. Army, Corps of Engineers, Baltimore District, for Phase I hydrologic and hydraulic evaluations. The analysis has been performed utilizing a modified version of the HEC-1 program developed by the U. S. Army, Corps of Engineers, Hydrologic Engineering Center, Davis, California. Analytical capabilities of the program are briefly described in the preface contained in Appendix D.

5.5 Summary of Analysis.

a. Spillway Design Flood (SDF). In accordance with procedures and guidelines contained in the National Guidelines For Safety Inspection of Dams for Phase I Investigations, the Spillway Design Flood (SDF) for Lebanon Reservoir Dam No. 1 ranges between the 1/2 PMF (Probable Maximum Flood) and the PMF. This classification is based on the relative size of the dam (small), and the potential hazard

of dam failure to downstream developments (high). Due to the high potential for loss of life and damage to downstream structures, the SDF for this facility is considered to be the PMF.

b. Results of Analysis.

Lebanon Reservoir Dam No. 1 was evaluated under near normal operating conditions. That is, the reservoir was initially at its normal pool or service spillway crest elevation of approximately 622.5 feet with the spillway discharging freely. The outlet conduit was assumed to be non-functional for the purpose of analysis. In any event, the flow capacity of the outlet conduit is not such that it would significantly increase the total discharge capabilities of the dam and reservoir. The primary discharge facilities consist of a service spillway and an adjacent emergency spillway. The service spillway consists of a broad-crested weir which discharges into a natural channel. The emergency spillway is comprised of a broad-crested weir which discharges into a rectangular chute channel.

Lebanon Reservoir Dam No. 2, located immediately upstream of Dam No. 1, was also evaluated in this analysis to determine its effects on Dam No. 1. It also was investigated under near normal operating conditions. That is, the reservoir was initially at its normal pool or spillway crest elevation of approximately 676.0 feet, with the spillway discharging freely and the outlet conduit closed. The spillway consists of a broad-crested weir which discharges into a natural channel. It was assumed that the outflow of Dam No. 2 discharged directly into the lower reservoir. All pertinent engineering calculations relative to the evaluation of Lebanon Reservoir Dam No. 1, including those pertaining to the upstream facility are included in Appendix D.

Overtopping analysis (using the Modified HEC-1 Computer Program) indicated that the discharge/storage capacity of Lebanon Reservoir Dam No. 1 can accommodate only about 16 percent of the PMF (the SDF) prior to the overtopping of its embankment, while Lebanon Reservoir Dam No. 2 can accommodate only about 21 percent of the PMF before overtopping occurs (Appendix D, Summary Input/Output Sheet, Sheet L). The low top of embankment at Dam No. 1 was inundated by depths of 1.8 feet for 6.3 hours under 1/2 PMF conditions and 2.5 feet for 8.5 hours under PMF conditions. The low top of embankment at Dam No. 2 was inundated by a depth of about 0.9 feet for 6.5 hours under PMF conditions. Since the SDF for each of the facilities is the PMF, each has a high potential for overtopping, and thus, for breaching under floods of less than SDF magnitude.

Since neither of the dams can safely pass a flood of at least 1/2 PMF magnitude, the possibility of failure of each under floods of 1/2 PMF magnitude or less was investigated (in accordance with Corps directive ETL-1110-2-234). Several possible alternatives were examined since it is difficult, if not impossible, to determine exactly how or if a specific dam will fail. The dams were evaluated in series in order to ascertain the overall effect of the present system on the downstream population in the event of a severe storm. The major concern of the breaching evaluations is with the impact of the various breach discharges on increasing downstream water surface elevations above those to be expected if breaching did not occur.

The Modified HEC-1 Computer Program was used for the breaching analysis with the assumption that the breaching of an earth dam would begin once its reservoir's water level reached the low top of dam elevation.

For each of the two dams, five possible modes of failure were investigated. Two sets of breach geometry were evaluated for each of two failure times (Appendix D, Sheet 23). The two sets of breach sections chosen were considered to be the minimum and maximum probable failure sections. The two failure times (total time for each breach section to reach its final dimensions), under which the minimum and maximum sections were investigated, were assumed to be a rapid time (0.5 hours) and a prolonged time (4.0 hours), so that a range of this most sensitive variable might be examined. In addition, an average possible set of breach conditions was analyzed, with a failure time of 2.0 hours.

The five failure plans described above were analyzed under 0.24 PMF conditions to ensure overtopping of both dams. In all cases, the breaching of the downstream Lebanon Reservoir Dam No. 1 began about 30 minutes ahead of the failure of the upstream Lebanon Reservoir Dam No. 2 (Appendix D, Sheet 25).

The peak breach outflows (resulting from 0.24 PMF conditions) at Lebanon Reservoir Dam No. 1 ranged from about 1810 cfs for the minimum section-maximum fail time scheme to about 8380 cfs for the maximum section-minimum fail time scheme (Appendix D, Sheet 25). The outflow from the average breach scheme was about 3520 cfs, compared to the non-breach 0.24 PMF outflow of approximately 740 cfs (Summary Input/Output Sheets, Sheets U and L).

At a section located about 2700 feet downstream from Lebanon Reservoir Dam No. 1 (Section 2, see Figure 1, Appendix E), the water surface elevation corresponding to the non-breach 0.24 PMF peak outflow was approximately 544.3 feet while the peak water surface elevation corresponding to the maximum section-minimum fail time breach scheme was about 546.4 feet (Appendix D, Sheet 26). The elevation of the residence at Section 2 is approximately 545 feet. Therefore, the increase in water surface elevation caused by the failures of Lebanon Reservoir Dams Nos. 1 and 2 was about 2.1 feet, with the breach water surface above the damage level of the house.

At Section 3 (see Figure 1), located approximately 4550 feet downstream of Dam No. 1, the maximum breach water surface elevation was about 533.8 feet, well below the damage level of the residences at about 538 feet (Summary Input/Output Sheets, Sheet V).

The water surface elevation corresponding to the non-breach 0.24 PMF peak outflow was approximately 520.4 feet at a section located about 6050 feet downstream from Lebanon Dam Reservoir No. 1 (Section 4, see Figure 1). The peak water surface elevation corresponding to the maximum section-minimum fail time breach scheme was about 522.6 (Appendix D, Sheet 26). The residence at Section 4 is approximately at elevation 520 feet. Thus, the increase in water surface elevation due to the breaches was about 2.2 feet, with the breach water surface above the damage level of the house.

At Section 5 (see Figure 1), located about 8650 feet downstream from Dam No. 1, the non-breach 0.24 PMF peak outflow resulted in a water surface elevation of approximately 503.9 feet. The maximum section-minimum fail time scheme resulted in a peak elevation of 507.5 feet, an increase of 3.6 feet (Appendix D, Sheet 26). The breach water surface level was above the damage level of the residence at Section 5, approximately at elevation 504.

The consequences of dam failure can be better envisioned if not only the increase in the height of the floodwave is considered, but also the great increase in the momentum of the larger and probably swifter moving volume of water. Therefore, the failures of Lebanon Reservoir Dams Nos. 1 and 2 are quite possible, and would probably lead to increased property damage and possibly to loss of life in the downstream regions.

5.6 Spillway Adequacy.

As presented previously, under existing conditions, Lebanon Reservoir Dam No. 1 can accommodate only about 16 percent of the PMF prior to overtopping. Should a 0.24 PMF or larger event occur, the dam would be overtopped and could possibly fail, endangering downstream residences and increasing the potential for loss of life in the downstream regions. Therefore, the spillway is considered to be seriously inadequate.

SECTION 6
EVALUATION OF STRUCTURAL INTEGRITY

6.1 Visual Observations.

a. Embankment. The embankment is considered to be in fair condition. Lack of adequate maintenance has resulted in overgrown slopes and a generally poor appearance; nevertheless, no evidence of excess embankment stresses, slope instability, or seepage through the downstream embankment face was observed. Heavy overgrowth across the embankment slopes and along the downstream toe hamper visual observation of critical conditions and should be removed.

b. Appurtenant Structures.

1. Service Spillway. The service spillway appears structurally sound and is presently in good condition.

2. Emergency Spillway. The condition of the emergency spillway is considered poor. The lower portion of the discharge channel is deteriorated, characterized by severe concrete scaling, extensive cracking and some slab uplifting. Without proper maintenance, it is possible that high flows could further damage the deteriorating spillway structure and possibly endanger the embankment.

3. Outlet Conduit. The outlet conduit is reportedly functional; however, it was not operated in the presence of the inspection team. Minor seepage (≈ 2 gpm) was observed emanating around the conduit within the downstream valve chamber. This condition should be specifically addressed in future inspection and changes in flow rate and/or turbidity recorded. It is noted that control is not provided at the upstream end of the pipe. Should a leak or rupture develop within the conduit upstream of the gate valve along the downstream slope, there presently is no means of stopping the flow and thus, it is possible that serious erosion and/or instability could result.

6.2 Design and Construction Techniques.

No information is available that details the methods of design and/or construction.

6.3 Past Performance.

According to available correspondence and discussions

with representatives of the owner, the facility has performed satisfactorily since its last renovation in 1938.

6.4 Seismic Stability.

The dam is located within Seismic Zone No. 1 and, thus may be subject to minor earthquake induced dynamic forces. As the facility appears well constructed and sufficiently stable, it is believed that it can withstand the expected dynamic forces; however, no calculations and/or investigations were performed to confirm this belief.

SECTION 7
ASSESSMENT AND RECOMMENDATIONS FOR REMEDIAL MEASURES

7.1 Dam Assessment.

a. Safety. The visual inspection indicates the facility is inadequately maintained and in fair condition.

The size classification of the facility is small and its hazard classification is considered to be high. In accordance with the recommended guidelines, the Spillway Design Flood (SDF) for the facility ranges between the 1/2 PMF (Probable Maximum Flood) and the PMF. Due to the high potential for damage to downstream structures and possibly loss of life, the SDF is considered to be the PMF. Results of the hydrologic and hydraulic analysis indicate the facility will pass and/or store only about 16 percent of the PMF prior to embankment overtopping. A breach analysis indicates that failure under less than 1/2 PMF conditions could lead to increased downstream damage and potential for loss of life. Thus, based on screening criteria contained in the recommended guidelines, the spillway is considered to be seriously inadequate and the facility unsafe, non-emergency.

Deficiencies noted by the inspection team included heavy overgrowth across the embankment crest and slopes, rodent burrows along the downstream embankment face, a deteriorated emergency spillway, and minor seepage beneath the emergency spillway and around the outlet conduit. These deficiencies are, for the most part, attributable to a general lack of adequate maintenance since the facility was phased out of operation in 1973.

b. Adequacy of Information. The available data are considered sufficient to make a reasonable Phase I assessment of the facility.

c. Urgency. The recommendations listed below should be implemented immediately.

d. Necessity for Additional Investigations. Additional investigations are considered necessary and are listed in Section 7.2 below.

7.2 Recommendations/Remedial Measures.

It is recommended that the owner immediately:

a. Develop a formal emergency warning system to notify downstream residents should hazardous conditions develop. Included in the plan should be provisions for around-the-clock surveillance of the facility during periods of unusually heavy precipitation.

b. Have the facility evaluated by a registered professional engineer experienced in hydrology and hydraulic structures and take remedial measures deemed necessary to make the facility hydraulically adequate and the emergency spillway structurally sound.

c. Clear all excess vegetation from the embankment crest and slopes. In addition, all burrowing animals inhabiting the embankment should be exterminated and their burrows filled.

d. Develop formal manuals of operation and maintenance to ensure future proper care of the facility.

e. Specifically address in all future inspections the seepage conditions beneath the emergency spillway and around the outlet conduit at the downstream embankment toe noting changes in turbidity and/or rate of flow.

f. Provide upstream (inlet end) control of flow through the outlet conduit or develop a plan to control flow through the conduit at the inlet in the event emergency conditions develop in the pipe within the embankment.

APPENDIX A

VISUAL INSPECTION CHECKLIST AND FIELD SKETCHES

CHECK LIST
VISUAL INSPECTION
PHASE 1

NAME OF DAM Lebanon Reservoir Dam No. 1 STATE Pennsylvania COUNTY Lebanon

NDI # PA — 00595 PENNDER # 38-1

TYPE OF DAM Earth SIZE Small HAZARD CATEGORY High

DATE(S) INSPECTION 8 November 1979 WEATHER Ptly cloudy TEMPERATURE 40° @ Noon

POOL ELEVATION AT TIME OF INSPECTION 622.7 M.S.L.

TAILWATER AT TIME OF INSPECTION N/A M.S.L.

INSPECTION PERSONNEL	OWNER REPRESENTATIVES	*OTHERS*
B. M. Mihalcin	None Present	
D. L. Bonk		
D. J. Spaeder		

RECORDED BY B. M. Mihalcin

EMBANKMENT

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS NDI# PA - 00595
SURFACE CRACKS	None observed.
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None observed.
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	None observed.
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Horizontal - good. Vertical - good.
RIPRAP FAILURES	Riprap patchy, but, no significant erosion was observed.
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Good.

EMBANKMENT

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS NDI# PA - 00595
DAMP AREAS IRREGULAR VEGETATION (LUSH OR DEAD PLANTS)	No damp areas were observed on the downstream embankment face. Heavy overgrowth, including trees and thick brush, covers the entire embankment.
ANY NOTICEABLE SEEPAGE	No evidence of seepage through the downstream embankment face was observed. Minor seepage ($\leq$ 1 gpm) observed emanating from beneath the discharge end of the emergency spillway. Seepage or leakage ($\simeq$ 2 gpm) observed around the blowoff conduit within the valve chamber located at the downstream embankment toe.
STAFF GAGE AND RECORDER	None.
DRAINS	Three 6-inch diameter clay drains project through the downstream rock toe and discharge into a small rock-lined ditch parallel to the toe. Very small discharge on day of inspection. Two more 6-inch clay drains discharge into the channel several feet downstream of the blowoff conduit and apparently drain the left side of the embankment. Another drain was observed beneath the center of the downstream end of the emergency spillway.

OUTLET WORKS

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS NDI# PA - 00595
INTAKE STRUCTURE	Blowoff intake was submerged and could not be observed.
OUTLET CONDUIT (CRACKING AND SPALLING OF CONCRETE SURFACES)	16-inch diameter cast iron blowoff pipe.
OUTLET STRUCTURE	Valve chamber at downstream end of blowoff line. Concrete in good condition, but, hatch doors on top unattached and susceptible to vandalism.
OUTLET CHANNEL	Natural channel-unobstructed.
GATE(S) AND OPERATIONAL EQUIPMENT	Two apparent valves on blowoff line. One in valve chamber at toe of dam is not operable. A second valve stem was observed in a curb box structure about mid-height on the downstream slope of the dam. This valve reportedly controls blowoff discharge.

EMERGENCY SPILLWAY

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS NDI# PA - 00595
TYPE AND CONDITION	Concrete chute channel in poor condition.
APPROACH CHANNEL	N/A.
SPILLWAY CHANNEL AND SIDEWALLS	Channel floor-severely scaled and cracked. Some slab uplifting apparent and seepage through joints was observed. Many joints contain swamp willow shrubs.
STILLING BASIN PLUNGE POOL	See below.
DISCHARGE CHANNEL	The emergency spillway discharges into a broad, flat, agricultural area located immediately downstream of the dam. The natural stream channel is physically defined by a line of trees and brush that divides adjoining fields and pastures.
BRIDGE AND PIERS EMERGENCY GATES	The remnants of a steel supported footbridge span both the service and emergency spillways. Only the steel supports remain while all planking has been removed.

SERVICE SPILLWAY

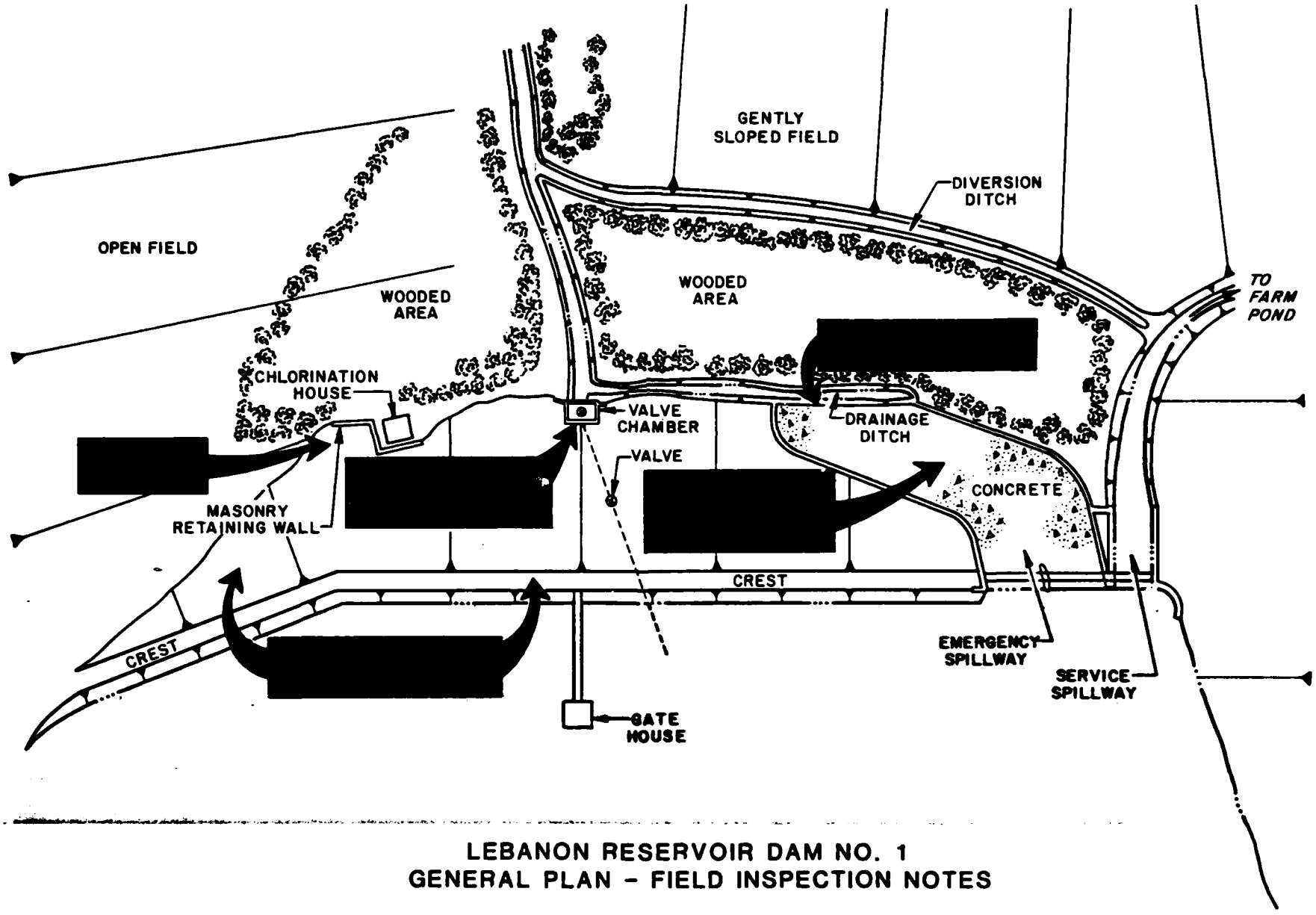
ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS NDI# PA- 00595
TYPE AND CONDITION	Concrete chute channel with masonry wingwalls in good condition.
APPROACH CHANNEL	N/A.
OUTLET STRUCTURE	N/A.
DISCHARGE CHANNEL	Trapezoidal-shaped rock-lined channel. Small flows are directed into a shallow farm pond located several hundred feet downstream and to the east of the facility. Larger flows apparently overtop the left channel bank, approximately 150 feet downstream of the spillway crest and discharge into a diversion channel that routes flow to the original stream channel downstream of the outlet conduit.

INSTRUMENTATION

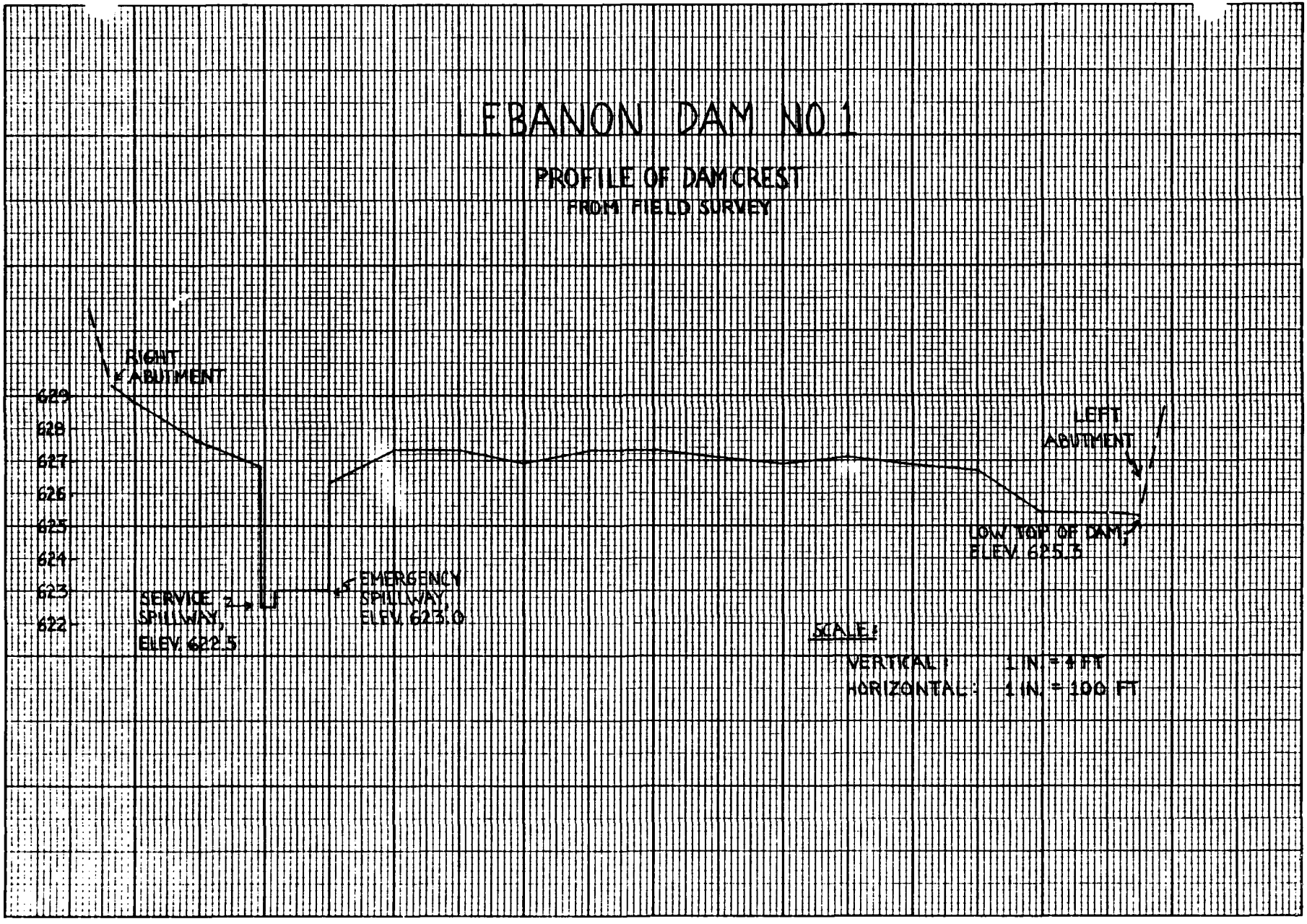
ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS NDI# PA - 00595
MONUMENTATION SURVEYS	None.
OBSERVATION WELLS	None.
WEIRS	None.
PIEZOMETERS	None.
OTHERS	

RESERVOIR AREA AND DOWNSTREAM CHANNEL

ITEM	OBSERVATIONS/REMARKS/RECOMMENDATIONS NDI# PA - 00595
SLOPES: RESERVOIR	The dam is located at the foot of heavily forested, steep slopes. The reservoir is flanked to the northeast and west by gently to moderately sloped farmland.
SEDIMENTATION	None observed.
DOWNSTREAM CHANNEL (OBSTRUCTIONS, DEBRIS, ETC.)	Low flows through the service spillway are routed through a small man-made channel that directs discharge downstream and to the right of the facility. Larger flows from the emergency spillway are routed into the original stream immediately downstream of the embankment below the outlet conduit.
SLOPES: CHANNEL VALLEY	Gently sloped farmlands.
APPROXIMATE NUMBER OF HOMES AND POPULATION	There are approximately 1/2 dozen homes and farms located along the stream within several miles of the dam. It is estimated that 20 to 30 persons could be affected by a breach of the embankment.



LEBANON RESERVOIR DAM NO. 1
GENERAL PLAN - FIELD INSPECTION NOTES


LEBANON DAM NO 1
PROFILE OF DAM CREST
FROM FIELD SURVEY
RIGHT ABUTMENT
629
628
627
626
625
624
623
622
SERVICE SPILLWAY, ELEV. 622.5
EMERGENCY SPILLWAY, ELEV. 623.0
LEFT ABUTMENT
LOW TOP OF DAM, ELEV. 625.5
SCALE:
VERTICAL: 1 IN. = 4 FT
HORIZONTAL: 1 IN. = 100 FT

APPENDIX B

ENGINEERING DATA CHECKLIST

CHECK LIST
ENGINEERING DATA
PHASE I

NAME OF DAM Lebanon Reservoir Dam No. 1

ITEM	REMARKS NDI# PA - 00595
PERSONS INTERVIEWED AND TITLE	Edward M. Keener (City of Lebanon, Engineer). Chris Siegrist (Water Authority Superintendent).
REGIONAL VICINITY MAP	See Figure 1, Appendix E.
CONSTRUCTION HISTORY	Originally constructed in 1871. Designed by H.P.M. Birkinbine of Philadelphia, Pennsylvania. Overtopped and breached in 1925. Reconstructed in 1926. Additional modifications made in 1938.
AVAILABLE DRAWINGS	Several miscellaneous design drawings (no complete sets) are available from both the owner and PennDER.
TYPICAL DAM SECTIONS	See Figure 3, Appendix E.
OUTLETS: PLAN DETAILS DISCHARGE RATINGS	See Figures 2, 3, and 4, Appendix E. Discharge curves are not available.

CHECK LIST
ENGINEERING DATA
PHASE I
(CONTINUED)

ITEM	REMARKS	NDI# PA - 00595
SPILLWAY: PLAN SECTION DETAILS	See Figures 3 and 4, Appendix E.	
OPERATING EQUIP- MENT PLANS AND DETAILS	See Figures 2 and 3, Appendix E.	
DESIGN REPORTS	None available.	
GEOLOGY REPORTS	None available.	
DESIGN COMPUTATIONS: HYDROLOGY AND HYDRAULICS STABILITY ANALYSES SEEPAGE ANALYSES	None available.	
MATERIAL INVESTIGATIONS: BORING RECORDS LABORATORY TESTING FIELD TESTING	None available.	

CHECK LIST
ENGINEERING DATA
PHASE I
(CONTINUED)

ITEM	REMARKS	NDI# PA - 00595
BORROW SOURCES	Not known.	
POST CONSTRUCTION DAM SURVEYS	None recorded.	
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	The upper dam (referred to as Rexmont No. 2 Dam or Lebanon Reservoir Dam No. 2, NDI No. PA-00594, PennDER No. 38-2) was inspected in November, 1978 by Berger Associates, Inc., of Harrisburg, Pennsylvania. Results are contained in PennDER files in a report dated May, 1979.	
HIGH POOL RECORDS	Not known.	
MONITORING SYSTEMS	None.	
MODIFICATIONS	Dam was partially reconstructed in 1926 after overtopping and failing in 1925. Additional modifications were made in 1938 (see Section 2.1.b.1 and Figures 3 and 4, Appendix E).	

CHECK LIST
ENGINEERING DATA
PHASE I
(CONTINUED)

ITEM	REMARKS	NDI# PA - 00595
PRIOR ACCIDENTS OR FAILURES	Dam was overtopped and breached on July 25, 1925. No fatalities were recorded.	
MAINTENANCE: RECORDS MANUAL	None available.	
OPERATION: RECORDS MANUAL	None available.	
OPERATIONAL PROCEDURES	Essentially self-regulating. No specific operating procedures exist.	
WARNING SYSTEM AND/OR COMMUNICATION FACILITIES	None.	
MISCELLANEOUS	Dam used to supply water to City of Lebanon prior to 1973. Facility currently used strictly for recreational purposes. Blowoff and supply lines are all reportedly functional.	

GAI CONSULTANTS, INC.

CHECK LIST
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

NDI ID # PA-00595
PENNDER ID # 38-1

SIZE OF DRAINAGE AREA: 0.6 square miles (local); 1.2 square miles (total).

ELEVATION TOP NORMAL POOL: 622.5 STORAGE CAPACITY: 55 acre-feet

ELEVATION TOP FLOOD CONTROL POOL: - STORAGE CAPACITY: -

ELEVATION MAXIMUM DESIGN POOL: - STORAGE CAPACITY: -

ELEVATION TOP DAM: 625.3 STORAGE CAPACITY: 82 acre-feet.

SPILLWAY DATA

CREST ELEVATION: 662.5 feet (service); 623.0 feet (emergency).

TYPE: Uncontrolled rectangular chute channels.

CREST LENGTH: 10.5 feet (service; 37.8 feet (emergency).

CHANNEL LENGTH: 50 feet (service); 180 feet (emergency).

SPILLOVER LOCATION: Near right abutment.

NUMBER AND TYPE OF GATES: None.

OUTLET WORKS

TYPE: 16-inch diameter case iron blowoff conduit.

LOCATION: Near the center of the embankment.

ENTRANCE INVERTS: 602 feet (estimated zero storage elevation).

EXIT INVERTS: 594.9 feet.

EMERGENCY DRAWDOWN FACILITIES: 16-inch diameter gate valve.

HYDROMETEOROLOGICAL GAGES

TYPE: None.

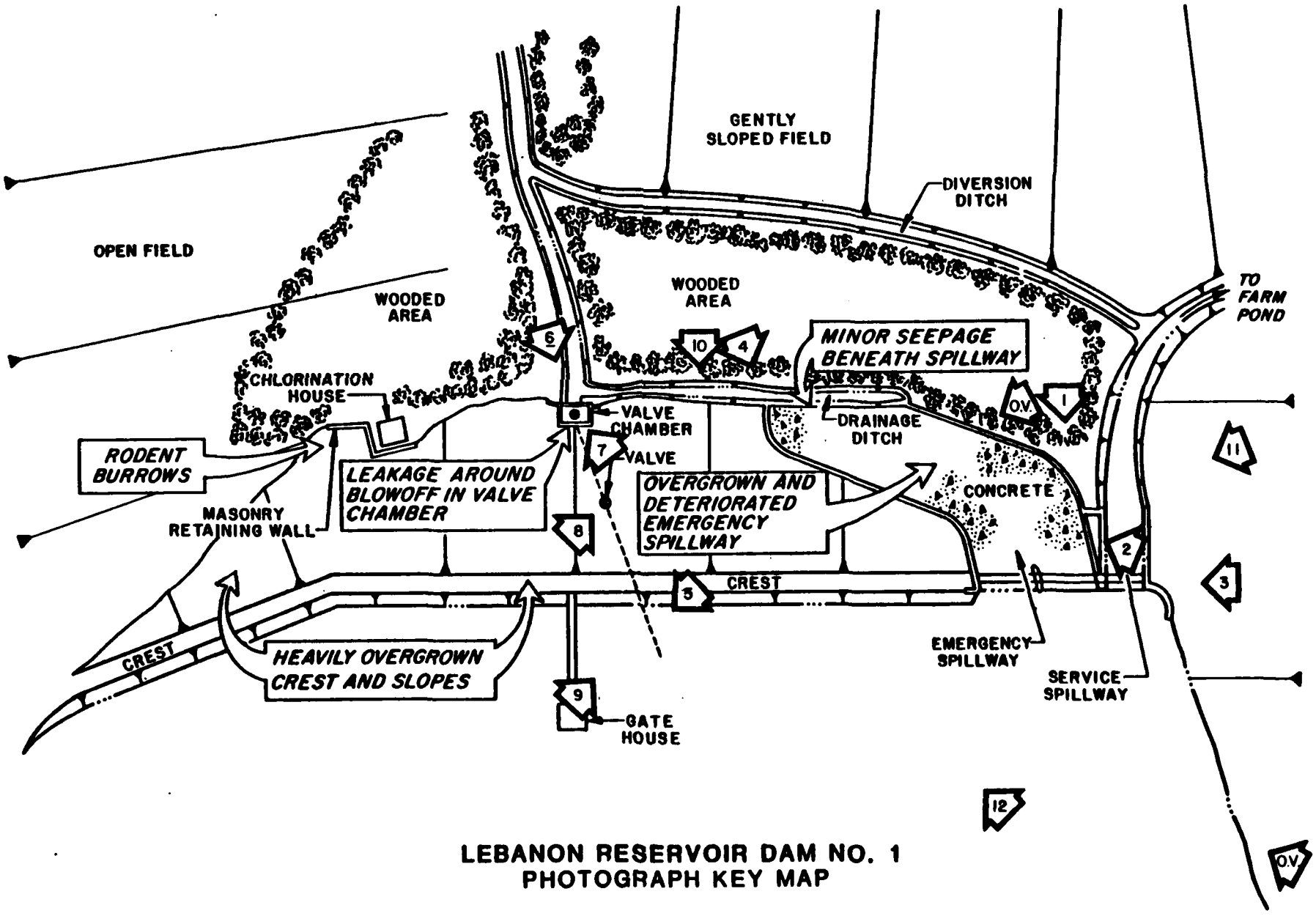
LOCATION: -

RECORDS: -

MAXIMUM NON-DAMAGING DISCHARGE: Not known.

APPENDIX C

PHOTOGRAPHS



LEBANON RESERVOIR DAM NO. 1
PHOTOGRAPH KEY MAP

PHOTOGRAPH 1 View, looking upstream, of the spillways at Lebanon Reservoir Dam No. 1.

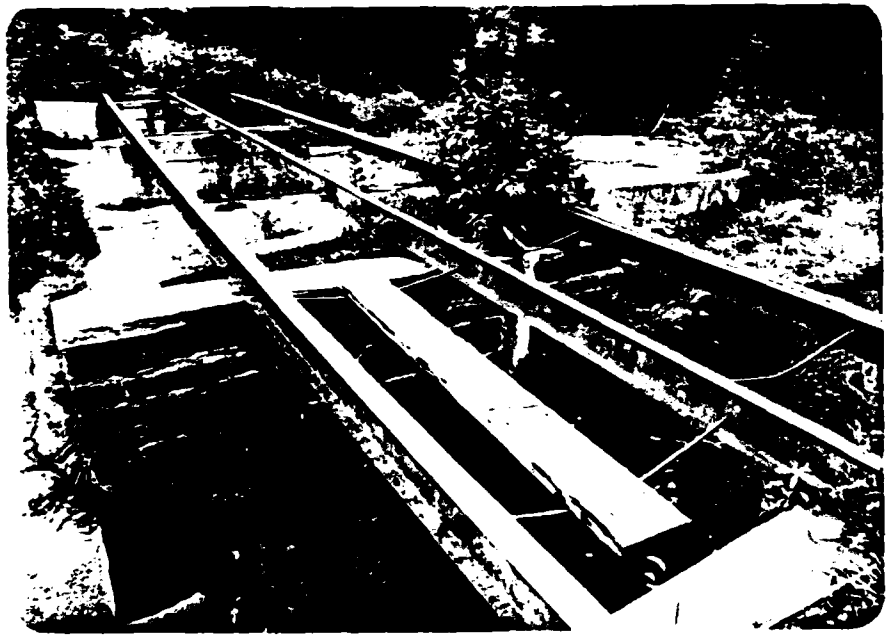
PHOTOGRAPH 2 View of the emergency spillway channel as seen from the service spillway.

PHOTOGRAPH 3 View of the spillways as seen from atop the right wingwall of the service spillway.

PHOTOGRAPH 4 View, looking upstream, of the discharge end of the emergency spillway channel. Note the heavy overgrowth.

1

2



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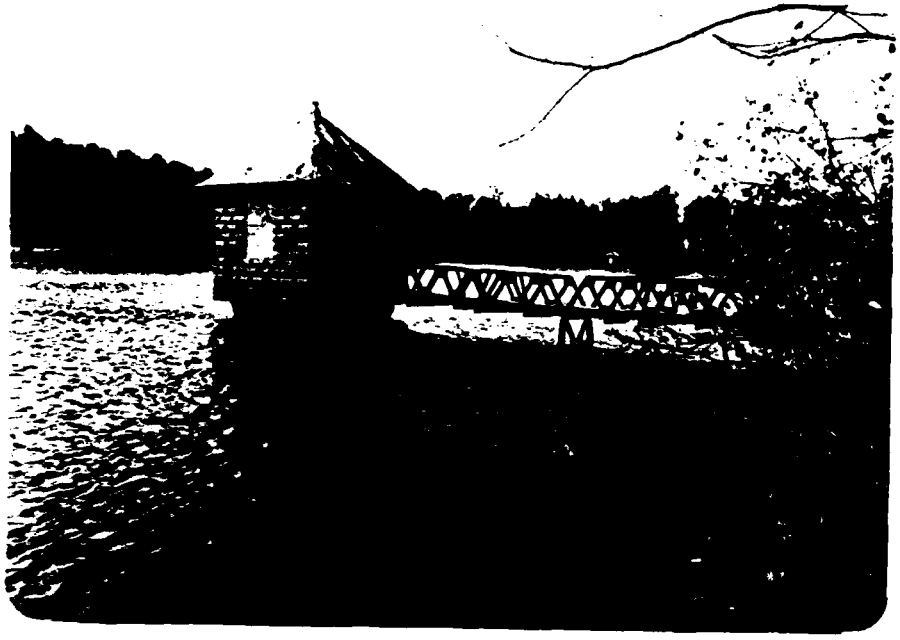
PHOTOGRAPH 5 View of the boarded-up masonry gate house located along the upstream embankment slope.

PHOTOGRAPH 6 View of the discharge end of the outlet conduit.

PHOTOGRAPH 7 View of the interior of the valve chamber located at the downstream embankment toe. Leakage observed around the outlet conduit within the chamber was estimated at about 2 gpm. The valve within the chamber is reportedly inoperable.

PHOTOGRAPH 8 View of the curb box accessing the stem of an outlet conduit valve near the middle of the downstream slope to the right (looking downstream) of the valve chamber.



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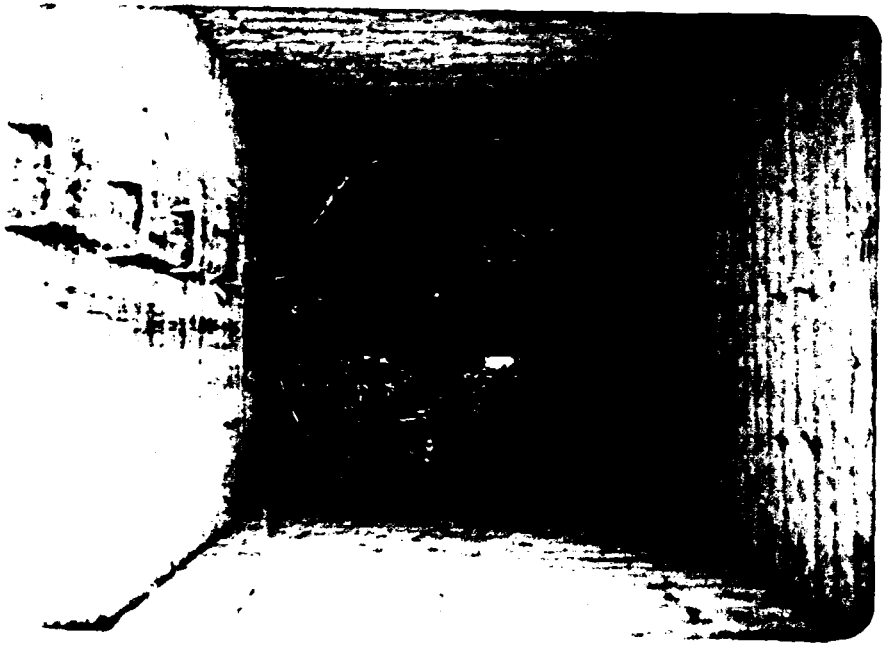

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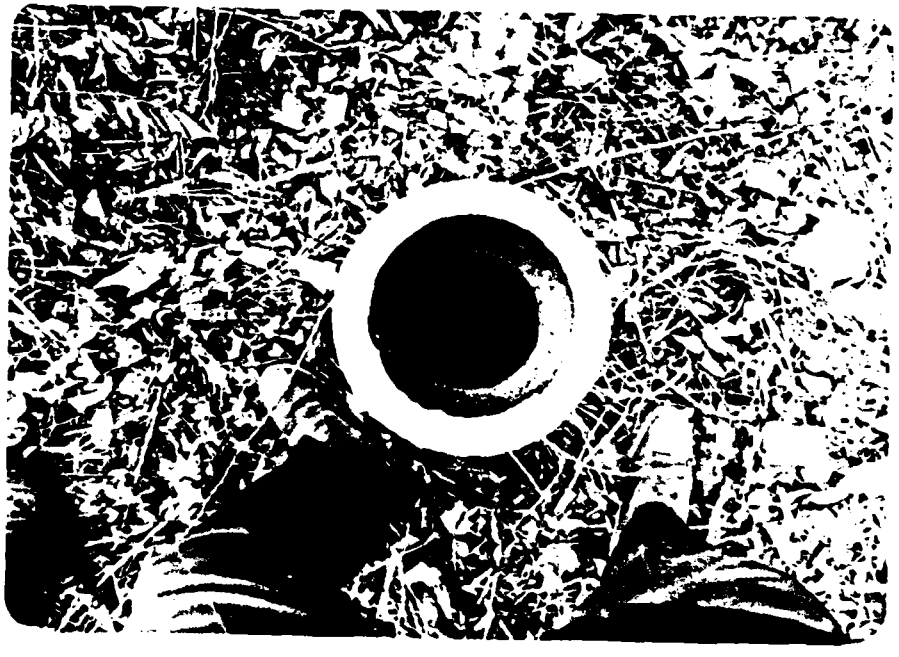

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PHOTOGRAPH 9 View of the upstream embankment face as seen from the gate house footbridge.

PHOTOGRAPH 10 View of a 6-inch diameter clay pipe drain discharging into a small rock-lined ditch that parallels the downstream embankment toe between the emergency spillway and outlet conduit.

PHOTOGRAPH 11 1959 view of the embankment as seen from the right abutment (note: compare with Overview Photograph of downstream face).

PHOTOGRAPH 12 1959 view of Lebanon Reservoir Dam No. 1 as seen from atop the crest of Lebanon Reservoir Dam No. 2.

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APPENDIX D

HYDROLOGY AND HYDRAULICS ANALYSES

PREFACE

The modified HEC-1 program is capable of performing two basic types of hydrologic analyses: 1) the evaluation of the overtopping potential of the dam; and 2) the estimation of the downstream hydrologic-hydraulic consequences resulting from assumed structural failures of the dam. Briefly, the computational procedures typically used in the dam overtopping analysis are as follows:

a. Development of an inflow hydrograph(s) to the reservoir.

b. Routing of the inflow hydrograph(s) through the reservoir to determine if the event(s) analyzed would overtop the dam.

c. Routing of the outflow hydrograph(s) from the reservoir to desired downstream locations. The results provide the peak discharge(s), time(s) of the peak discharge(s), and the maximum stage(s) of each routed hydrograph at the downstream end of each reach.

The evaluation of the hydrologic-hydraulic consequences resulting from an assumed structural failure (breach) of the dam is typically performed as shown below.

a. Development of an inflow hydrograph(s) to the reservoir.

b. Routing of the inflow hydrograph(s) through the reservoir.

c. Development of a failure hydrograph(s) based on specified breach criteria and normal reservoir outflow.

d. Routing of the failure hydrograph(s) to desired downstream locations. The results provide estimates of the peak discharge(s), time(s) to peak and maximum water surface elevations of failure hydrographs for each location.

HYDROLOGY AND HYDRAULIC ANALYSIS
DATA BASE

NAME OF DAM: LEBANON RESERVOIR DAM NO. 1

PROBABLE MAXIMUM PRECIPITATION (PMP) = 23.2 INCHES/24 HOURS (1)

STATION	1	2		3
STATION DESCRIPTION	Dam No. 2	Dam No. 1		
DRAINAGE AREA (SQUARE MILES)	0.6	0.6		
CUMULATIVE DRAINAGE AREA (SQUARE MILES)	-	1.2		
ADJUSTMENT OF PMF FOR DRAINAGE AREA LOCATION (%)(1)	Zone 6	Zone 6		
6 HOURS	113	113		
12 HOURS	123	123		
24 HOURS	132	132		
48 HOURS	143	143		
72 HOURS	-	-		
SNYDER HYDROGRAPH PARAMETERS				
ZONE (2)	15c	15c		
C_p (3)	0.82	0.82		
C_t (3)	2.78	2.78		
L (MILES) (4)	1.10	1.9		
L_{ca} (MILES) (4)	0.51	1.1		
$t_p = C_t (L \cdot L_{ca})^{0.3}$ (HOURS)	2.34	3.47		
SPILLWAY DATA		(5)	(6)	
CREST LENGTH (FEET)	14.5	10.5	37.8	
FREEBOARD (FEET)	3.8	2.8	2.3	

(1) HYDROMETEOROLOGICAL REPORT 33, U.S. ARMY CORPS OF ENGINEERS, 1956

(2) HYDROLOGIC ZONE DEFINED BY CORPS OF ENGINEERS, BALTIMORE DISTRICT, FOR DETERMINATION OF SNYDER COEFFICIENTS (C_p AND C_t).

(3) SNYDER COEFFICIENTS

(4) L = LENGTH OF LONGEST WATERCOURSE FROM DAM TO BASIN DIVIDE.
L_{ca} = LENGTH OF LONGEST WATERCOURSE FROM DAM TO POINT OPPOSITE BASIN CENTROID.

(5) SERVICE SPILLWAY

(6) EMERGENCY SPILLWAY

ECT DAM SAFETY INSPECTION
LEBANON DAM No. 1

BY JTS DATE 1-11-80 PROJ. NO. 79-203-595

CHKD. BY DLB DATE 1-31-80 SHEET NO. 1 OF 36

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DAM STATISTICS

- HEIGHT OF DAM = 30 FEET (FIELD MEASUREMENT)

- NORMAL POOL STORAGE CAPACITY = 18×10^6 GALLONS
  = 55.2 ACRE-FT (SEE NOTE 1)

- MAXIMUM POOL STORAGE CAPACITY = 82 ACRE-FT (HEC-1 OUTPUT)

- DRAINAGE AREA = 0.63 = 0.6 SQ. MI. (PLANIMETERED ON USGS 7.5 MINUTE TOPO MAPS: RICHLAND AND LEBANON, PA.)

- ELEVATION OF TOP OF DAM (DESIGN) = 626.0 (FIGURE 3)

- ELEVATION OF TOP OF DAM (FIELD) = 625.3

- NORMAL POOL ELEVATION = 622.5 (FIGURE 3 AND FIELD NOTES)

- UPSTREAM INLET INVERT ELEVATION = 603 (FIGURE 2)

- DOWNSTREAM OUTLET INVERT (FIELD) = 594.9

- STREAMBED AT DAM CENTERLINE = 598.0 (ESTIMATE)

NOTE 1: OBTAINED FROM "REPORT UPON DAM No. 1 OF THE LEBANON CITY WATER WORKS," DECEMBER, 1914, FOUND IN PENNDER FILES.

SUBJECT Dam Safety Inspection
Lebanon Dam No. 2

BY DJS DATE 1-11-80 PROJ. NO. 79-303-595

CHKD. BY DLG DATE 1-31-80 SHEET NO. 2 OF 26

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Dam Classification

Dam Size: Small (Ref 1, Table 1)

Hazard Classification: High (Field Observation)

Required SDF: ½ PMF to PMF (Ref 1, Table 3)

Hydrograph Parameters

Length of Longest Watercourse: $L = 1.9$ miles

Length of Longest Watercourse from Dam to a Point Opposite Basin Centroid: $L_{CA} = 1.1$ miles

{Measured on USGS Topo Quads: Lebanon and Richland, PA.}

$C_t = 2.78$
$C_p = 0.89$

{Supplied by COE, Zone 15C, Susquehanna River Basin.}

Snyder's Standard Lag: $t_p = C_t (L \cdot L_{CA})^{0.3}$

$= 2.78 (1.9 \times 1.1)^{0.3}$

$= 3.47$ hours

(Note: Hydrograph variables used here are defined in Reference 3, in section entitled "Snyder Synthetic Unit Hydrograph.")

SUBJECT Dam Safety Inspection
Lebanon Dam No. 1

BY DJS DATE 1-11-80 PROJ. NO. 79-303-595

CHKD. BY DLB DATE 1-31-80 SHEET NO. 3 OF 26

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Reservoir Capacity

Reservoir Surface Areas:

Surface Area (S.A.) at Normal Pool (Elev 622.5) = 8.5 acres
S.A. @ Elev 640 = 23.7 acres

(Planimetered on U.S.G.S. Topo Quad, Richland, PA)

Elevation of Low Top of Dam = 625.3 (Field Notes)
By linear interpolation between elevations 640 and 622.5,

SA @ Elev 625.3 = 10.9 acres

Reservoir Elevation @ "0" Storage

Storage @ Normal Pool = 1/3 HA (Assumed Conic Relationship)

Storage = 55.2 acre-ft
Surface Area (A) = 8.5 acres
} @ Normal Pool

$$\therefore H = \frac{(3)(55.2)}{(8.5)} = 19.5 \text{ ft}$$

Zero Storage Elevation = 622.5 − 19.5 = 603.0

Note: In order to compute an elevation-storage relationship, with a storage volume of 55.2 ac-ft at elevation 622.5, the above computed zero storage elevation must be used in the HEC-1 Program. The calculated elevation seems to be a reasonable estimate of the actual minimum reservoir elevation, based on available design drawings.

SUBJECT DAM SAFETY INSPECTION
LEBANON DAM No. 1
BY DJS DATE 1-11-80 PROJ. NO. 79-203-595
CHKD. BY DLA DATE 1-31-80 SHEET NO. 4 OF 26

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RESERVOIR ELEVATION - STORAGE RELATIONSHIP:

THE ELEVATION-STORAGE RELATIONSHIP IS COMPUTED INTERNALLY BY THE HEC-1 PROGRAM, BASED ON THE ELEVATION/SURFACE AREA DATA GIVEN ON SHEET 3. THE CONIC METHOD IS USED TO ESTIMATE STORAGE VOLUMES.

PMP CALCULATIONS

APPROXIMATE RAINFALL INDEX IS 27.2 INCHES, CORRESPONDING TO A DURATION OF 24 HOURS AND AN AREA OF 200 SQUARE MILES, LOCATED IN SOUTHEASTERN PENNSYLVANIA. (REF 3, FIG. 1)

- DEPTH-AREA-DURATION ZONE #6 (REF 3, FIG. 1)

- DRAINAGE AREA = 0.6 SQUARE MILES; ASSUME DATA CORRESPONDING TO A 10-SQUARE MILE AREA IS REPRESENTATIVE OF THIS BASIN:

DURATION (HRS)	PERCENT OF INDEX RAINFALL
6	113
12	123
24	132
48	143

(REF 3, FIG. 2)

- HOP BROOK FACTOR (ADJUSTMENT FOR BASIN SHAPE AND FOR THE LESSER LIKELIHOOD OF A SEVERE STORM CENTERING OVER A SMALL BASIN) FOR A DRAINAGE AREA OF 0.6 SQUARE MILES IS 0.80. (REF 4, p. 48)

PROJECT DAM SAFETY INSPECTION
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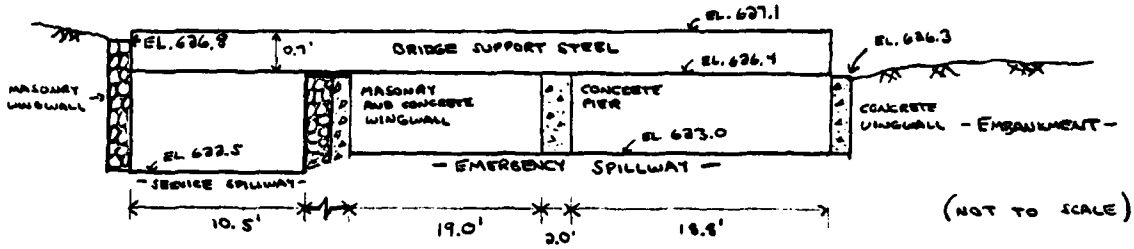
SPILLWAY CAPACITY

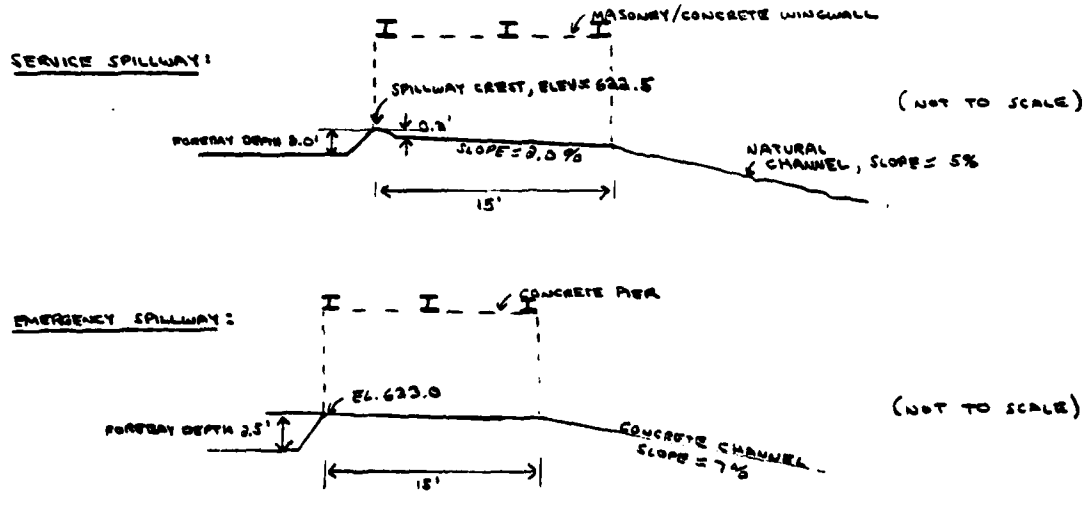
SPILLWAY CROSS-SECTION:



(NOT TO SCALE)

— SECTION LOOKING UPSTREAM —

SPILLWAY PROFILES:



(NOT TO SCALE)

- BASED ON FIELD NOTES AND DESIGN DRAWINGS,

FIGURE 3

PROJECT DAM SAFETY INSPECTION
LEBANON DAM No. 1

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THE PRIMARY DISCHARGE FACILITIES CONSIST OF A SERVICE SPILLWAY AND AN ADJACENT EMERGENCY SPILLWAY. THE SERVICE SPILLWAY CONSISTS OF A BROAD-CRESTED WEIR WHICH DISCHARGES INTO A NATURAL CHANNEL. THE EMERGENCY SPILLWAY IS ESSENTIALLY COMPRISED OF A BROAD-CRESTED WEIR WHICH DISCHARGES INTO A RECTANGULAR CHUTE CHANNEL.

DISCHARGE OVER EACH WEIR CAN BE ESTIMATED BY THE RELATION

$$Q = CLH^{3/2}$$ (REF 5, p. 5-23)

WHERE Q = DISCHARGE OVER THE WEIR, IN CFS,
C = DISCHARGE COEFFICIENT,
L = LENGTH OF WEIR CREST, IN FEET,
H = TOTAL HEAD ON CREST, IN FEET.

SERVICE SPILLWAY CAPACITY:

THE CREST OF THE SERVICE SPILLWAY IS AT ELEVATION 628.5. THE LENGTH OF THE CREST IS APPROXIMATELY 10.5 FEET. THE DISCHARGE COEFFICIENT WILL BE ASSUMED TO BE ON THE ORDER OF 2.6. THIS SLIGHTLY CONSERVATIVE VALUE SHOULD ACCOUNT FOR ANY MINOR APPROACH LOSSES OR ENTRANCE LOSSES WHICH MAY EXIST, AS WELL AS ANY EFFECTS DUE TO THE BRIDGE SUPPORT STEEL. (REF 5, TABLE 5-3)

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SERVICE SPILLWAY RATING TABLE:

	RESERVOIR ELEVATION (FT)	H (FT)	Q* (CFS)	RESERVOIR ELEVATION (FT)	H (FT)	Q* (CFS)
	622.5	0	0	628.0	5.5	350
	623.0	0.5	10	629.0	6.5	450
	624.0	1.5	50	630.0	7.5	560
	625.0	2.5	110	631.0	8.5	680
(LOW TOP OF DAM)	625.3	2.8	130	632.0	9.5	800
	626.0	3.5	190	633.0	10.5	930
	627.0	4.5	260	635.0	12.5	1210

* $Q = CLH^{3/2} = (2.6)(10.5)(H^{3/2})$
$= 27.3\,H^{3/2}$

EMERGENCY SPILLWAY CAPACITY:

THE CREST OF THE EMERGENCY SPILLWAY IS APPROXIMATELY AT ELEVATION 623.0. THE EFFECTIVE LENGTH OF THE CREST IS 19.0 + 18.8, OR 37.8 FEET. A DISCHARGE COEFFICIENT OF ABOUT 2.6 IS ASSUMED. THIS SLIGHTLY CONSERVATIVE VALUE SHOULD ACCOUNT FOR ANY MINOR PIER LOSSES, APPROACH LOSSES, BRIDGE CHORD LOSSES, ETC., WHICH MAY EXIST.

(REF 5, TABLE 5-3)

SUBJECT DAM SAFETY INSPECTION
LEBANON DAM No. 2

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EMERGENCY SPILLWAY RATING TABLE :

	RESERVOIR ELEVATION (FT)	H (FT)	Q* (CFS)	RESERVOIR ELEVATION (FT)	H (FT)	Q* (CFS)
	623.0	0	0	629.0	6.0	1440
	624.0	1.0	100	630.0	7.0	1820
	625.0	2.0	290	631.0	8.0	2220
(LOW TOP OF DAM)	625.3	2.3	340	632.0	9.0	2650
	626.0	3.0	510	633.0	10.0	3110
	627.0	4.0	790	635.0	12.0	4090
	628.0	5.0	1100			

$$Q = CLH^{3/2} = (2.6)(37.8)H^{3/2} = 99.3\,H^{3/2}$$

EMBANKMENT RATING CURVE

ASSUME THAT THE EMBANKMENT BEHAVES ESSENTIALLY AS A BROAD-CRESTED WEIR WHEN OVERTOPPED. THUS, THE DISCHARGE CAN BE ESTIMATED BY THE RELATIONSHIP

$$Q = CLH^{3/2} \qquad \text{(REF 5, p. 5-23)}$$

WHERE Q = DISCHARGE OVER EMBANKMENT, IN CFS,
L = LENGTH OF EMBANKMENT OVERTOPPED, IN FEET,
H = HEAD ON WEIR; IN THIS CASE, IT IS THE AVERAGE "FLOW-AREA" WEIGHTED HEAD ABOVE THE CREST, USING THE LOW TOP OF DAM AS THE DATUM,
C = COEFFICIENT OF DISCHARGE; DEPENDENT ON THE HEAD AND THE WEIR BREADTH.

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ASSUME THAT INCREMENTAL DISCHARGES FOR SUCCESSIVE RESERVOIR ELEVATIONS ARE APPROXIMATELY TRAPEZOIDAL IN CROSS-SECTIONAL FLOW AREA. THEN ANY INCREMENTAL AREA OF FLOW (BETWEEN SPECIFIED RESERVOIR ELEVATIONS) IS APPROXIMATELY EQUAL TO $H_i [(L_1+L_2)/2]$, WHERE L_1 = LENGTH OF OVERTOPPED EMBANKMENT AT HIGHER ELEVATION, L_2 = LENGTH AT LOWER ELEVATION, H_i = DIFFERENCE IN ELEVATIONS. THUS, THE TOTAL AVERAGE "FLOW-AREA" WEIGHTED HEAD, H_w, IS APPROXIMATELY EQUAL TO (TOTAL FLOW AREA / L_2).

EMBANKMENT RATING TABLE:

RESERVOIR ELEVATION (FT)	① L_1 (FT)	L_2 (FT)	INCREMENTAL HEAD, H_i (FT)	② INCREMENTAL FLOW AREA, A_i (FT^2)	TOTAL FLOW AREA, A_T (FT^2)	③ WEIGHTED HEAD, H_w (FT)	④ H_w/l	⑤ C	⑥ Q (CFS)
625.3	0	0	0	0	0	0	0	—	0
625.4	25	0	0.1	1	1	0	0	—	0
626.0	100	25	0.6	38	39	0.4	0.03	3.01	80
626.7	125	100	0.7	79	118	0.9	0.08	3.03	330
626.9	210	125	0.2	34	152	0.7	0.06	3.03	370
627.0	330	210	0.1	27	179	0.6	0.05	3.03	450
627.3	560	330	0.3	132	311	0.6	0.05	3.03	790
627.6	680	560	0.3	186	497	0.7	0.06	3.03	1310
628.0	700	680	0.4	276	773	1.1	0.09	3.04	2460
629.0	750	700	1.0	725	1498	2.0	0.17	3.06	6490
630.0	790	750	1.0	770	2268	2.9	0.24	3.08	13,330
631.0	830	790	1.0	805	3073	3.7	0.31	3.09	19,030
632.0	850	830	1.0	835	3908	4.6	0.38	3.09	25,910
633.0	880	850	1.0	865	4773	5.4	0.45	3.09	34,130
635.0	950	880	2.0	1830	6603	6.9	0.58	3.09	53,310

① FROM FIELD MEASUREMENTS AND USGS TOPO

② $A_i = H_i\left(\frac{L_1+L_2}{2}\right)$

③ $H_w = A_T/L_1$

④ l = BREADTH OF DAM = 12 FT

⑤ $C = f(H, l)$, FROM REF 12, FIG 24

⑥ $Q = CL_1H_w^{3/2}$

ECT DAM SAFETY INSPECTION
LEBANON DAM No. 1

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TOTAL FACILITY RATING TABLE

$Q_{TOTAL} = Q_{SERVICE} + Q_{EMERGENCY} + Q_{EMBANKMENT}$

	Reservoir Elevation (Ft)	$Q_{SERVICE}$ (CFS)	$Q_{EMERGENCY}$ (CFS)	$Q_{EMBANKMENT}$ (CFS)	Q_{TOTAL} (CFS)
	623.5	0	–	–	0
	624.0	10	0	–	10
	624.0	50	100	–	150
	625.0	110	280	–	390
(LOW TOP OF DAM)	625.3	130	340	0	470
	626.0	180	510	80	770
	626.7	240 *	710 *	320	1270
	626.9	250 *	760 *	370	1380
	627.0	260	790	450	1500
	627.3	290 *	880 *	790	1960
	627.6	310 *	980 *	1210	2500
	628.0	350	1100	2460	3910
	629.0	450	1440	6490	8380
	630.0	560	1820	12,020	14,400
	631.0	680	2220	18,030	20,930
	632.0	800	2650	25,910	29,360
	633.0	930	3110	34,120	38,160
	635.0	1210	4090	53,310	58,510

* BY LINEAR INTERPOLATION

PROJECT DAM SAFETY INSPECTION
LEBANON DAM No. 1

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LEBANON DAM No. 2

DAM STATISTICS

- HEIGHT OF DAM = 49 FEET (FIELD MEASUREMENT)
- NORMAL POOL STORAGE CAPACITY = 150 ACRE-FT (SEE NOTE 1)
- MAXIMUM POOL STORAGE CAPACITY = 187 ACRE-FT (SHEET 4)
- DRAINAGE AREA = 0.6 SQUARE MILES {PLANIMETERED ON USGS TOPS: RICHLAND AND LEBANON, PA}
- ELEVATION OF TOP OF DAM = 679.8 (FIELD MEASUREMENT)
- NORMAL POOL ELEVATION = 676.0 (SEE NOTE 1)

NOTE 1: THESE VALUES WERE OBTAINED FROM "PHASE I INSPECTION REPORT, NATIONAL DAM INSPECTION PROGRAM, REXMONT No. 2 DAM", BY BERGER ASSOCIATES, HARRISBURG, PA, MAY, 1979.

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LEBANON DAM NO. 1

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LEBANON DAM NO. 2

DAM CLASSIFICATION ✓

DAM SIZE : INTERMEDIATE
HAZARD CLASSIFICATION : HIGH (SEE NOTE 1)
REQUIRED SDF : PMF

HYDROGRAPH PARAMETERS ✓

LENGTH OF LONGEST WATERCOURSE : $L = 1.10$ MILES

LENGTH OF LONGEST WATERCOURSE FROM DAM TO A POINT OPPOSITE BASIN CENTROID : $L_{CA} = 0.51$ MILES

$C_t = 2.78$
$C_p = 0.82$

SNYDER'S STANDARD LAG : $t_p = C_t (L \cdot L_{CA})^{0.3}$
$= 2.78 (1.10 \times 0.51)^{0.3}$
$= 2.34$ HOURS

(SEE NOTE 1)

RESERVOIR CAPACITY ✓

RESERVOIR SURFACE AREAS :

- S.A @ ELEV 680 = 10.0 ACRES
- S.A @ ELEV 700 = 15.3 ACRES

{ PLANIMETERED ON USGS TOPO QUAD : RICHLAND, PA }

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S.A. @ ELEV. 645 = 0.7 ACRES
S.A. @ ELEV 650 = 2.0 ACRES
S.A. @ ELEV 660 = 4.6 ACRES
S.A @ ELEV 676 (NORMAL POOL) = 8.3 ACRES

{ FROM PLATE III, REYMONT NO. 2 DAM, PHASE I REPORT. SEE NOTE 1 }

IT IS ASSUMED THAT THE MODIFIED PRISMOIDAL RELATIONSHIP ADEQUATELY MODELS THE RESERVOIR SURFACE AREA - STORAGE RELATIONSHIP. SINCE THE CAPACITY AT NORMAL POOL IS KNOWN, THE CALCULATED VOLUMES CAN BE ADJUSTED ACCORDINGLY.

$$\Delta V_{1-2} = \frac{h}{3}\left(A_1 + A_2 + \sqrt{A_1 \cdot A_2}\right) \qquad \text{(REF 14, p.15)}$$

WHERE ΔV_{1-2} = INCREMENTAL VOLUME BETWEEN ELEVATIONS 1 & 2, IN FEET,
h = ELEVATION 2 - ELEVATION 1, IN FEET,
A_1 = S.A. @ ELEV 1, IN ACRES,
A_2 = S.A. @ ELEV 2, IN ACRES.

IT IS ALSO ASSUMED THAT SURFACE AREA VARIES LINEARLY BETWEEN THE KNOWN VALUES GIVEN ABOVE.

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Lebanon Dam No. 2

ELEVATION - STORAGE TABLE:

	RESERVOIR ELEVATION (FT)	AREA (ACRES)	ΔV_{1-2} (AC-FT)	INITIAL CALCULATED TOTAL VOLUME (AC-FT)	FINAL CALCULATED VOLUME ** (AC-FT)
	640.0	0	—	—	0
	645.0	0.7	1.2	1.2	1
	650.0	2.0	6.5	7.7	8
	655.6	3.3 *	13.1	20.8	22
	660.0	4.6	19.6	40.4	42
	665.0	5.8 *	25.9	66.3	69
	670.0	6.9 *	31.7	98.0	102
(NORMAL POOL)	676.0	8.3	45.5	143.5	150
	677.0	8.7 *	8.5	152.0	159
	678.0	9.2 *	8.9	160.9	168
	679.0	9.6 *	9.4	170.3	178
(LOW TOP OF DAM)	679.8	9.9 *	7.8	178.1	186
	680.0	10.0	2.0	180.1	188
	681.0	10.3 *	10.1	190.2	199
	682.0	10.5 *	10.4	200.6	210
	683.0	10.8 *	10.6	211.2	221
	684.0	11.1 *	10.9	222.1	232
	685.0	11.3 *	11.2	233.3	244

* BY LINEAR INTERPOLATION

** FINAL CALCULATED VOLUME = (INITIAL CALCULATED VOLUME) x (CORRECTION FACTOR)

WHERE CORRECTION FACTOR = $\left(\frac{\text{KNOWN VALUE AT NORMAL POOL}}{\text{INITIAL CALC. VOL. AT NORMAL POOL}}\right)$

$= \frac{150}{143.5} = 1.045$

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LEBANON DAM No. 2

PMP CALCULATIONS

APPROXIMATE RAINFALL INDEX IS 23.2 INCHES, CORRESPONDING TO A DURATION OF 24 HOURS AND AN AREA OF 200 SQUARE MILES, LOCATED IN SOUTHEASTERN PENNSYLVANIA. (REF 3, FIG. 1)

- DEPTH-AREA-DURATION ZONE 6. (REF 3, FIG. 1)

- DRAINAGE AREA = 0.6 SQUARE MILES; ASSUME DATA CORRESPONDING TO A 10-SQUARE MILE AREA IS REPRESENTATIVE OF THIS BASIN:

DURATION	PERCENT OF INDEX RAINFALL
6	113
12	123
24	132
48	143

(REF 3, FIG. 2)

HAP BROOK FACTOR (ADJUSTMENT FOR BASIN SHAPE AND FOR THE LESSER LIKELIHOOD OF A SEVERE STORM CENTERING OVER A SMALL BASIN) FOR A DRAINAGE AREA OF 0.6 SQUARE MILES IS 0.80. (REF 4, p. 48)

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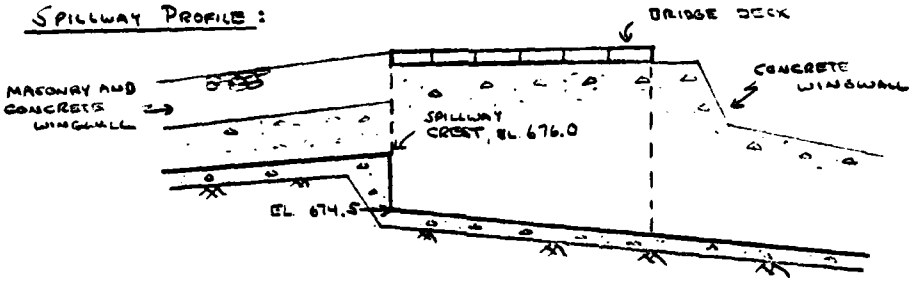
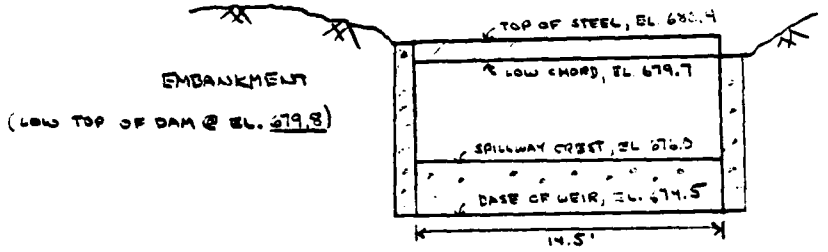
LEBANON DAM No. 2

SPILLWAY PROFILE:



(NOT TO SCALE)

SPILLWAY CROSS-SECTION:



(NOT TO SCALE)

- SECTION LOOKING UPSTREAM -

(- FROM FIELD MEASUREMENTS)

SPILLWAY CAPACITY

THE SPILLWAY CONSISTS OF WHAT IS ESSENTIALLY A BROAD-CRESTED WEIR DISCHARGING INTO A NATURAL CHANNEL. A RATING CURVE FOR THE SPILLWAY HAS BEEN DEVELOPED (SEE NOTE 1), USING THE WEIR EQUATION, $Q = CLH^{3/2}$. FOR THIS WEIR, THE LENGTH, L, IS 14.5 FEET, AND THE COEFFICIENT OF DISCHARGE, C, IS 3.2. THE MINOR APPROACH LOSSES AND ENTRANCE LOSSES WERE ASSUMED TO BE INSIGNIFICANT HERE. THE BRIDGE DECK WAS ASSUMED TO BE

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CASHED OUT UNDER HIGH FLOWS, AND THE STEEL SUPPORT BEAMS WERE ASSUMED TO HAVE NEGLIGIBLE EFFECTS ON DISCHARGE.

SPILLWAY RATING TABLE:

RESERVOIR ELEVATION (FT)	H (FT)	Q* (CFS)	RESERVOIR ELEVATION (FT)	H (FT)	Q* (CFS)
676.0	0	0	691.0	5.0	530
677.0	1.0	50	692.0	6.0	680
678.0	2.0	130	693.0	7.0	860
679.0	3.0	240	694.0	8.0	1050
679.8	3.8	340	695.0	9.0	1250
690.0	4.0	370			

* $Q = CLH^{3/2}$, $L = 14.5$, $C = 3.2$

EMBANKMENT RATING CURVE

ASSUME THAT THE EMBANKMENT BEHAVES ESSENTIALLY AS A BROAD-CRESTED WEIR UPON OVERTOPPING. THUS, THE DISCHARGE CAN BE ESTIMATED BY THE RELATION

$$Q = CLH^{3/2}$$ (REF 5, p. 5-23)

WHERE Q = DISCHARGE OVER EMBANKMENT, IN CFS,
L = LENGTH OF EMBANKMENT OVERTOPPED, IN FEET,
H = HEAD ON WEIR; IN THIS CASE, IT IS THE AVERAGE "FLOW-AREA" WEIGHTED HEAD ABOVE THE CREST (LOW TOP OF DAM),
C = COEFFICIENT OF DISCHARGE, DEPENDENT ON THE HEAD AND THE WEIR BREADTH.

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Assume that incremental discharges for successive reservoir elevations are approximately trapezoidal in cross-sectional flow area. Then any incremental area of flow (between specified reservoir elevations) is approximately equal to $H_i [(L_1 + L_2)/2]$, where L_1 = length of overtopped embankment at higher elevation, L_2 = length at lower elevation, H_i = elevation difference. Thus, the total average "flow-area" weighted head, $\underline{H_w}$, is approximately equal to (total flow area / L_1).

Embankment Rating Table:

Reservoir Elevation (Ft)	① Length Overtopped, L_1 (Ft)	L_2 (Ft)	Incremental Head, H_i (Ft)	③ Incremental Area, A_i (Ft^2)	Total Flow Area, A_T (Ft^2)	③ Weighted Head, H_w (Ft)	④ H_w/l	⑤ C	⑥ Q (cfs)
679.8	0	0	0	0	0	0	—	—	0
679.9	350	0	0.1	18	18	0.1	0.01	2.93	30
680.0	430	350	0.1	39	57	0.1	0.01	2.93	40
680.2	640	430	0.2	107	164	0.3	0.02	2.99	310
680.5	730	640	0.3	206	370	0.5	0.03	3.02	780
681.0	740	730	0.5	368	738	1.0	0.06	3.03	2340
682.0	750	740	1.0	745	1483	2.0	0.12	3.04	6450
683.0	770	750	1.0	760	2243	2.9	0.17	3.06	11,640
684.0	790	770	1.0	775	3018	3.9	0.23	3.08	18,500
685.0	790	790	1.0	785	3803	4.8	0.28	3.09	25,670

① From field measurements and USGS topo
③ $A_i = H_i [(L_1+L_2)/2]$
③ $H_w = A_T / L_1$
④ l = breadth of crest = 17 ft (avg.)
⑤ $C = f(H, l)$, from Ref 12, Fig. 34
⑥ $Q = C L_1 H_w^{3/2}$

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LEBANON DAM No. 1

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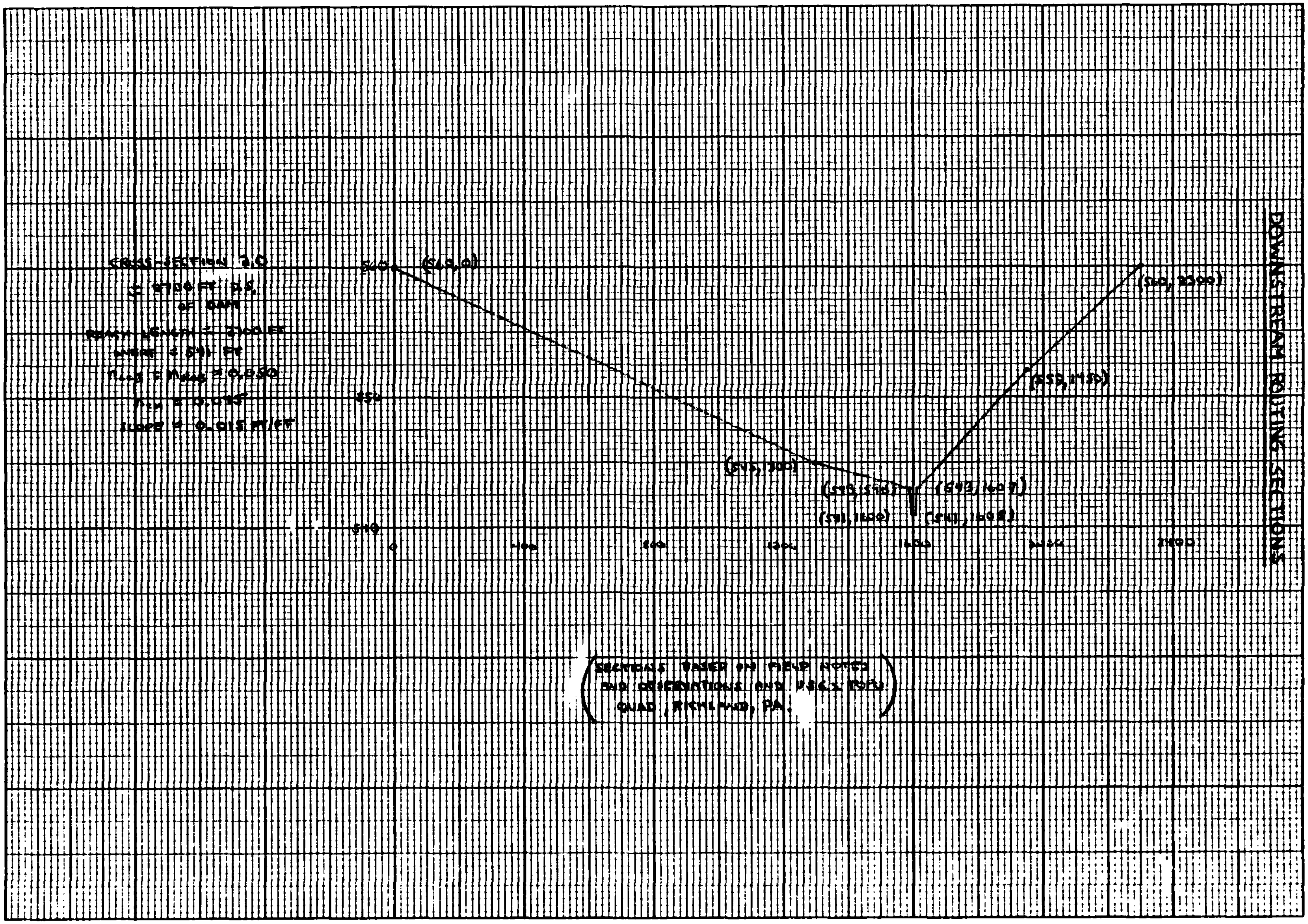
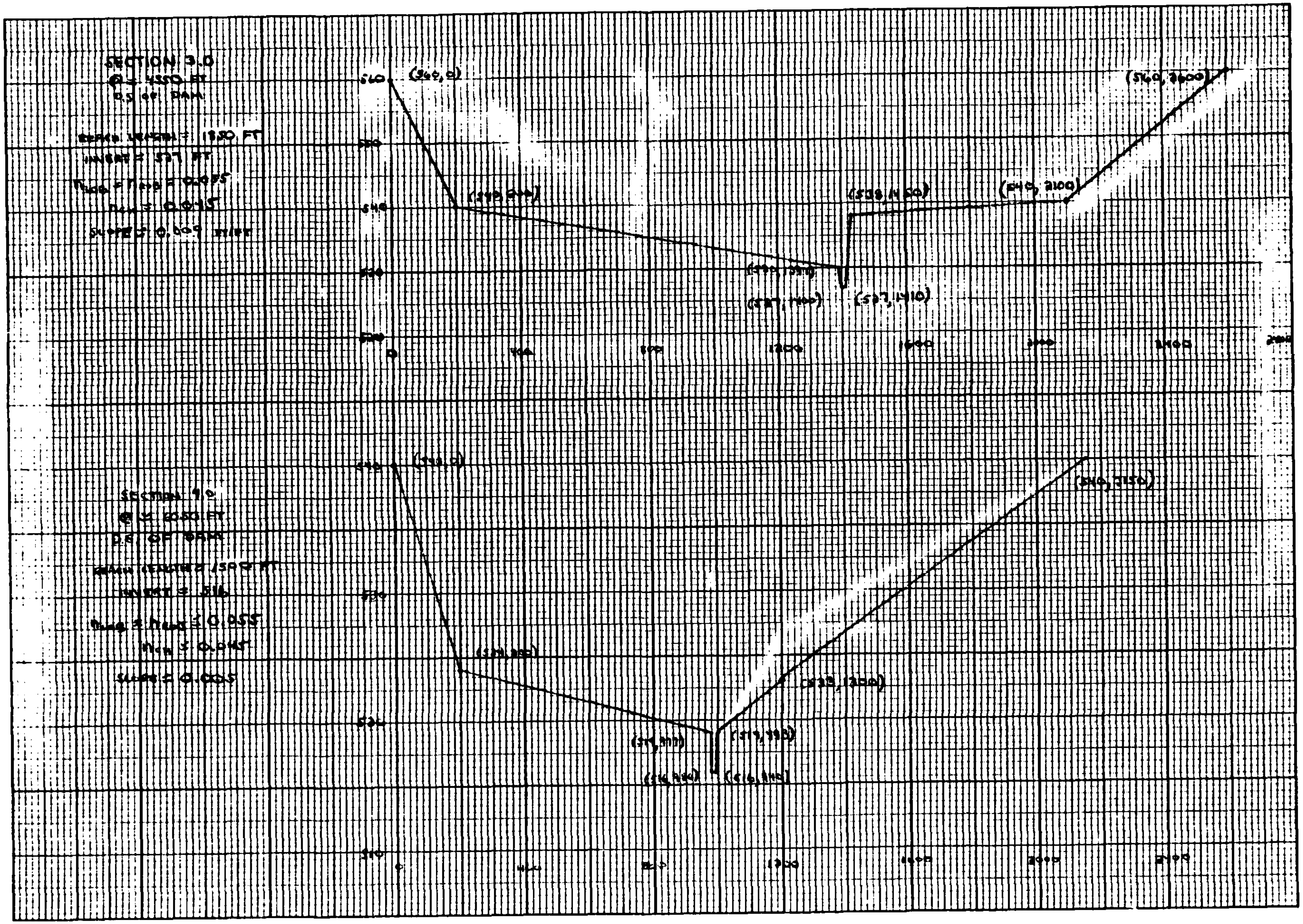
TOTAL FACILITY RATING TABLE

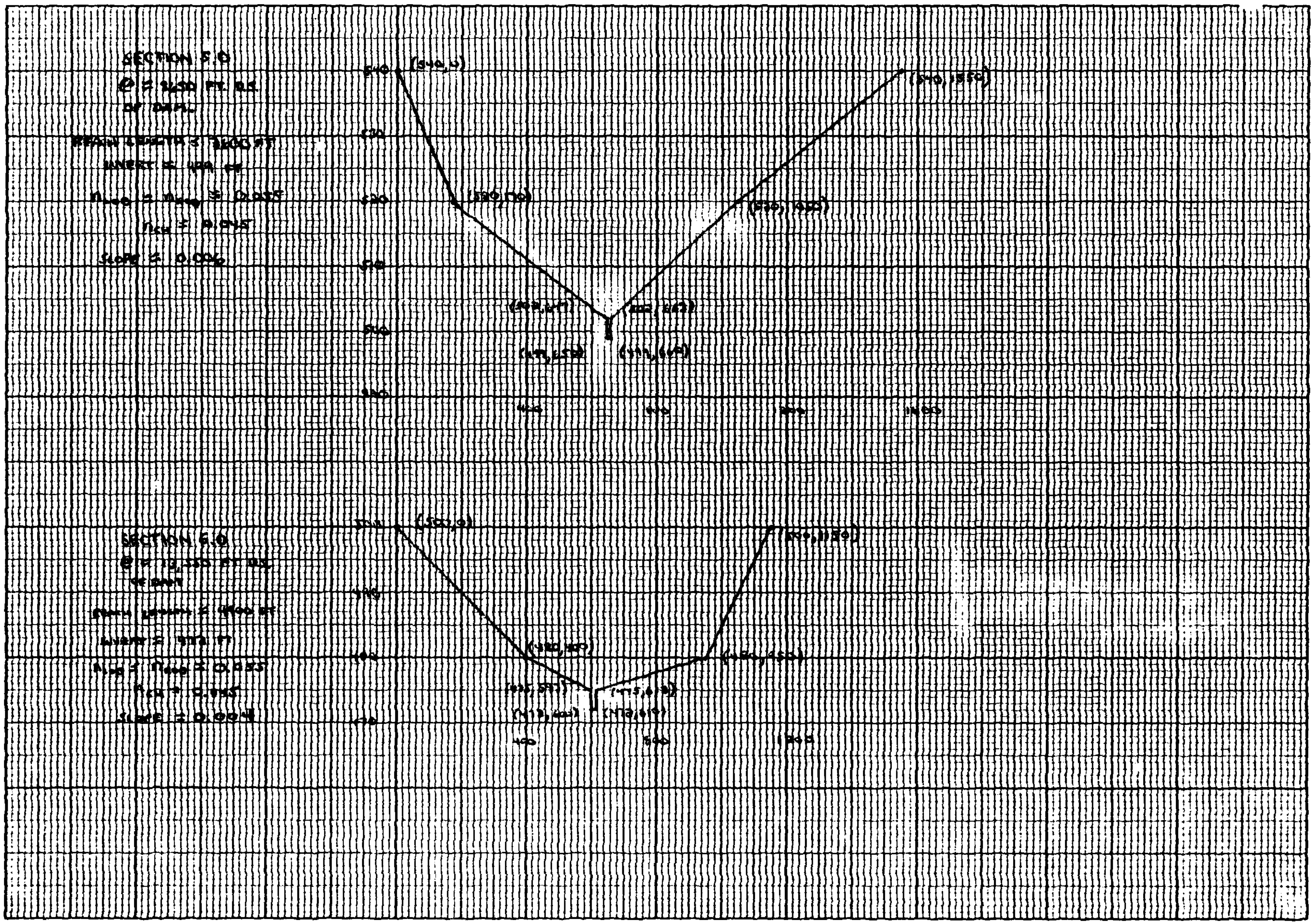
$Q_{TOTAL} = Q_{SPILLWAY} + Q_{EMBANKMENT}$

	RESERVOIR ELEVATION	$Q_{SPILLWAY}$	$Q_{EMBANKMENT}$	Q_{TOTAL}
	676.0	0	–	0
	677.0	50	–	50
	678.0	130	–	130
	679.0	240	–	240
(LOW TOP OF DAM)	679.8	340	0	340
	679.9	360 *	30	390
	680.0	370	40	410
	680.2	400 *	310	710
	680.5	450 *	780	1230
	681.0	520	2240	2760
	682.0	680	6450	7130
	683.0	860	11,640	12,500
	684.0	1050	18,500	19,550
	685.0	1250	25,670	26,920

* BY LINEAR INTERPOLATION


DOWNSTREAM ROUTING SECTIONS
SLOPE = 0.015 FT/FT
560
550
540
0
(560, 2300)
(550, 1750)
QUAD, RICHLAND, PA.


SECTION 3.0
@ ≅ 4550 FT
D.S. OF DAM
REACH LENGTH = 1820 FT
INVERT = 537 FT
SLOPE = 0.009 FT/FT
(560, 0)
(540, 240)
(538, 1400)
(540, 2100)
(560, 2600)
(537, 1410)
SECTION 4.0
D.S. OF DAM
INVERT = 516
SLOPE = 0.005
(533, 1200)
(540, 2150)



SECTION 5.0
SLOPE = 0.006
(540,0)
(540,1550)
SECTION 6.0
SLOPE = 0.004
(500,0)
(420,100)

PROJECT Dam Safety Inspection
Lebanon Dam No. 1

BY JJS DATE 1-29-80 PROJ. NO. 79-203-595

CHKD. BY DLB DATE 2-1-80 SHEET NO. 23 OF 26

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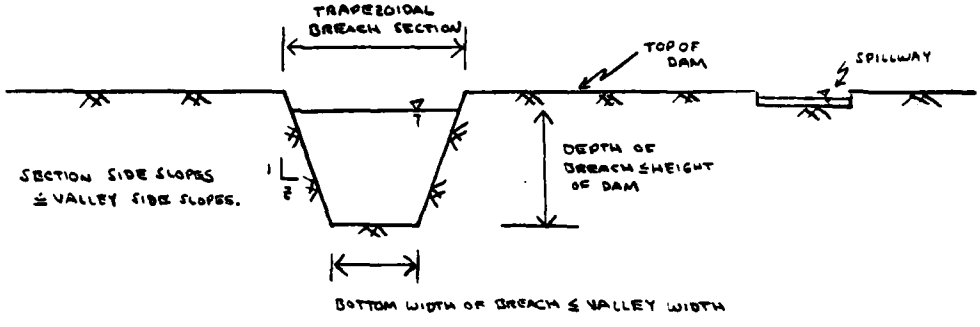
Breach Assumptions

Typical Breach Section:



HEC-1 Dam Breaching Analysis Input:

PLAN	Dam No. 1 Breach Bottom Width (ft)	Dam No. 1 Breach Depth (ft)	Dam No. 1 Section Sideslopes	Dam No. 1 Breach Time (hrs)*	Dam No. 2 Breach Bottom Width (ft)	Dam No. 2 Breach Depth (ft)	Dam No. 2 Section Sideslopes	Dam No. 2 Breach Time (hrs)*
① Min. section, min. fail time	0	22	1:1	0.5	0	40	1/3:1	0.5
② Max. section, min. fail time	300	22	8:1	0.5	300	40	5:1	0.5
③ Min. section max. fail time	0	22	1:1	4.0	0	40	1/3:1	4.0
④ Max section max. fail time	300	22	8:1	4.0	300	40	5:1	4.0
⑤ Average possible conditions	75	22	2:1	2.0	100	40	1:1	2.0

* Breach time is the total time needed to reach final breach dimensions.

JECT DAM SAFETY INSPECTION
LEBANON DAM No. 1

BY DJS DATE 1-29-80 PROJ. NO. 79-303-595

CHKD. BY DLB DATE 2-1-80 SHEET NO. 24 OF 26

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THE BREACH ASSUMPTIONS LISTED ON SHEET 23 ARE BASED SOMEWHAT ON INFORMATION CONCERNING EARTH DAM BREACHING PROVIDED BY THE C.O.E., BALTIMORE DISTRICT, AND ON THE PHYSICAL CONSTRAINTS OF THE DAM AND SURROUNDING TERRAIN.

DAM No. 1: (DOWNSTREAM DAM)

- MAX. DEPTH OF BREACH = TOP OF DAM - ZERO STORAGE ELEV (SHEET 3)
  = 625 - 603 = 22 FEET
- LENGTH OF BREACHABLE EMBANKMENT = 650 FT
- VALLEY BOTTOM WIDTH = 300 FT
- SIDE SLOPES: AVG. = 8:1
  (BASED ON RESERVOIR AND VALLEY GEOMETRY)

DAM No. 2: (UPSTREAM DAM)

- MAX. DEPTH OF BREACH = TOP OF DAM - MIN. RESERVOIR ELEV
  = 679.8 - 640 = 40 FT
- LENGTH OF BREACHABLE EMBANKMENT = 720 FT
- VALLEY BOTTOM WIDTH = 300 FT
- SIDE SLOPES: AVG. = 5:1
  (BASED ON RESERVOIR AND VALLEY GEOMETRY)

NOTE: THE CONSTRAINTS LISTED ABOVE ARE TAKEN FROM FIELD NOTES AND OBSERVATIONS, FROM USGS 7000, RICHLAND, PA, AND FROM FIGURE 3. THE BREACHABLE EMBANKMENT LENGTHS DO NOT INCLUDE SPILLWAY CREST LENGTHS.

ECT Dam Safety Inspection

Lebanon Dam No. 1

BY JJS DATE 1-4-80 PROJ. NO. 79-303-595

CHKD. BY DLB DATE 2-14-80 SHEET NO. 35 OF 36

HEC-1 DAM BREACHING ANALYSIS OUTPUT

RESERVOIR DATA:

UNDER 0.24 PMF BASE FLOW CONDITIONS:

RESERVOIR	PLAN NUMBER	VARIABLE BREACH BOTTOM WIDTH (FT) RESERVOIR NO. 2	VARIABLE BREACH BOTTOM WIDTH (FT) RESERVOIR NO. 1	ACTUAL MAXIMUM FLOW DURING FAIL TIME (CFS)	CORRESPONDING TIME OF FLOW (HRS)	INTERPOLATED OR HEC-1 ROUTED MAX FLOW DURING FAIL TIME (CFS)	CORRESPONDING TIME OF FLOW (HRS)	ACTUAL PEAK FLOW THROUGH DAM (CFS)	CORRESPONDING TIME OF FLOW (HRS)	TIME OF INITIAL BREACH (HRS)
	①	0	—	5887	42.33	5887	42.33	5887	42.33	41.83
	②	300	—	8125	42.00	8125	42.00	8125	42.00	41.83
LEBANON # 2	③	0	—	1074	44.33	1074	44.33	1074	44.33	41.83
	④	300	—	1512	42.17	1512	42.17	1512	42.17	41.83
	⑤	100	—	2338	42.29	2338	42.33	2338	42.29	41.83
	①	0	0	3412	41.83	3412	41.83	4333	42.50	41.33
	②	300	300	4980	41.47	4810	41.50	8375	42.00	41.33
LEBANON # 1	③	0	0	1809	44.50	1809	44.50	1809	44.50	41.33
	④	300	300	2398	42.25	2364	42.17	2398	42.25	41.33
	⑤	100	75	3518	42.33	3518	42.33	3518	42.33	41.33

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HEC-1 DAM BREACHING ANALYSIS OUTPUT:

DOWNSTREAM ROUTING DATA:

UNDER 0.24 PMF BASE FLOW CONDITIONS:

PLAN (1)	VARIABLE BREACH BOTTOM WIDTH (FT) RES.#2	RES.#1	OUTPUT AT SECTION 3, LOCATED 2700 FT D.S. FROM DAM #1 PEAK FLOW (CFS)	CORRESPONDING WSEL (2.) (FT)	WSEL (3) W/O BREACH (FT)	ΔELEV (4) (FT)	OUTPUT AT SECTION 4, LOCATED 6050 FT D.S. FROM DAM #1 PEAK FLOW (CFS)	CORRESPONDING WSEL (2.) (FT)	WSEL (3) W/O BREACH (FT)	ΔELEV (4) (FT)	OUTPUT AT SECTION 5, LOCATED 8650 FT D.S. FROM DAM #1 PEAK FLOW (CFS)	CORRESPONDING WSEL (2.) (FT)	WSEL (3) W/O BREACH (FT)	ΔELEV (4) (FT)
①	0	0	3979	545.8	544.3	+1.5	3544	522.2	520.4	+1.8	3410	506.9	503.9	+3.0
②	300	300	6417	546.4	544.3	+2.1	4795	522.6	520.4	+2.2	4194	507.5	503.9	+3.6
③	0	0	1793	545.1	544.3	+0.8	1772	521.3	520.4	+0.9	1758	505.6	503.9	+1.7
④	300	300	2294	545.2	544.3	+0.9	2224	521.6	520.4	+1.2	2180	505.9	503.9	+2.0
⑤	100	75	3427	545.6	544.3	+1.3	3328	522.1	520.4	+1.7	3151	506.7	503.9	+2.8

(1.) *SEE TABLE, SHEET 14*

(2.) *WATER SURFACE ELEVATIONS CORRESPONDING TO BREACH OUTFLOWS (SUMMARY INPUT/OUTPUT SHEETS, SHEETS U, V)*

(3.) *BASE FLOW ELEVATIONS CORRESPONDING TO THE PEAK 0.24 PMF AS INTERPOLATED FROM SHEET M, SUMMARY INPUT/OUTPUT SHEETS.*

(4.) *ΔELEV = (CORRESPONDING WSEL) − (WSEL W/O BREACH)*

OVERTOPPING ANALYSIS

DAM SAFETY INSPECTION
LEBANON DAM NO. 1 W/U.S. LEBANON DAM NO. 2 *** OVERTOPPING ANALYSIS ***
10-MINUTE TIME STEP AND 48-HOUR STORM DURATION

JOB SPECIFICATION

NO	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
288	0	10	0	0	0	0	0	0	0
			JOPER	NWT	LROPT	TRACE			
			5	0	0	0			

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLANS 1 NRTIO= 5 LRTIO= 1
RTIOS= .10 .20 .30 .50 1.00

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

RESERVOIR INFLOW - LEBANON DAM NO.2 RESERVOIR

	ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
AR =2		0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	.60	0.00	1.20	0.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	23.20	113.00	123.00	132.00	143.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .800

INITIAL AND CONSTANT RAINFALL LOSSES (C.O.E.)

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.05	0.00	0.00

UNIT HYDROGRAPH DATA
TP= 2.34 CP= .87 NTA= 0

BASE FLOW PARAMETERS (C.O.E.)

RECESSION DATA
STRTQ= -1.50 QRCSN= -.05 RTIOR= 2.00

APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC=18.96 AND R= 5.52 INTERVALS

UNIT HYDROGRAPH 41 END-OF-PERIOD ORDINATES, LAG= 2.34 HOURS, CP= .81 VOL= 1.00

3.	12.	24.	37.	51.	64.	78.	91.	104.	116.
126.	133.	137.	139.	138.	134.	129.	121.	110.	95.
79.	66.	55.	46.	38.	32.	27.	22.	19.	15.
13.	11.	9.	7.	6.	5.	4.	4.	3.	3.
2.									

END-OF-PERIOD FLOW

0												
MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
									SUM	26.54	24.13	2.41	35185.
										(674.)(613.)(61.)(1562.10)			

ECT Dam Safety Inspection

BY DSS DATE 2-14-80 Lebanon Dam No. 1

CHKD. BY DLR DATE 2-14-80 PROJ. NO. 79-203-595

SHEET NO. A OF V

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PROJECT Dam Safety Inspection

Lebanon Dam No. 1

BY DJL DATE 8-12-80 PROJ. NO. 79-203-595

CHKD. BY DLB DATE 8-14-80 SHEET NO. 8 OF V

LOCAL INFLOW HYDROGRAPHS, LEBANON DAM NO.2 RESERVOIR

0.1 PMF

CFS	178.	120	37.	19.	5515.
CMS	5.	3.	1.	1.	156.
INCHES		1.85	2.29	2.37	2.37
MM		47.07	58.20	60.32	60.32
AC-FT		59.	73.	76.	76.
THOUS CU M		73.	90.	94.	94.

0.2 PMF

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	356.	239.	74.	38.	11029.
CMS	10.	7.	2.	1.	312.
INCHES		3.71	4.58	4.75	4.75
MM		94.15	116.40	120.65	120.65
AC-FT		119.	147.	152.	152.
THOUS CU M		146.	181.	187.	187.

0.3PMF

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	534.	359.	111.	57.	16544.
CMS	15.	10.	3.	2.	468.
INCHES		5.56	6.87	7.12	7.12
MM		141.22	174.60	180.97	180.97
AC-FT		178.	220.	228.	228.
THOUS CU M		219.	271.	281.	281.

0.5 PMF

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	890.	598.	185.	96.	27573.
CMS	25.	17.	5.	3.	781.
INCHES		9.27	11.46	11.87	11.87
MM		235.36	291.00	301.62	301.62
AC-FT		296.	366.	380.	380.
THOUS CU M		366.	452.	468.	468.

PMF

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1781.	1195.	369.	191.	55146.
CMS	50.	34.	10.	5.	1562.
INCHES		18.53	22.91	23.75	23.75
MM		470.73	582.00	603.24	603.24
AC-FT		593.	733.	760.	760.
THOUS CU M		731.	904.	937.	937.

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

ROUTE THROUGH RESERVOIR

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPR	NAME	ISTAGE	IAUTO
AM =2	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP		LSTR
0.0	0.000	0.00	1	1	0	0		0

	NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
	1	0	0	0.000	0.000	0.000	150.	-1

STAGE	676.00	677.00	678.00	679.00	679.80	679.90	680.00	680.20	680.50	681.0
	682.00	683.00	684.00	685.00						
FLOW	0.00	50.00	130.00	240.00	340.00	390.00	410.00	710.00	1230.00	2760.0
	7130.00	12500.00	19550.00	26920.00						

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CAPACITY=	0.	1.	8.	22.	42.	69.	102.	150.	159.	168.
	178.	186.	188.	199.	210.	221.	232.	244.		
ELEVATION=	640.	645.	650.	655.	660.	665.	670.	676.	677.	678.
	679.	680.	680.	681.	682.	683.	684.	685.		

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
676.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
679.8	0.0	0.0	0.

PEAK OUTFLOW IS 151. AT TIME 42.67 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	151.	108.	35.	18.	5187.
CMS	4.	3.	1.	1.	147.
INCHES		1.67	2.16	2.23	2.23
MM		42.36	54.85	56.74	56.74
AC-FT		53.	69.	71.	71.
THOUS CU M		66.	85.	88.	88.

0.1 PMF

PEAK OUTFLOW IS 317. AT TIME 42.67 HOURS

LEBANON
DAM NO.2
OUTFLOW
HYDROGRAPHS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	317.	222.	71.	37.	10530.
CMS	9.	6.	2.	1.	298.
INCHES		3.45	4.39	4.53	4.53
MM		87.55	111.41	115.19	115.19
AC-FT		110.	140.	145.	145.
THOUS CU M		136.	173.	179.	179.

0.2 PMF

PEAK OUTFLOW IS 533. AT TIME 41.83 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	533.	340.	107.	55.	15934.
CMS	15.	10.	3.	2.	451.
INCHES		5.27	6.64	6.86	6.86
MM		133.76	168.62	174.29	174.29
AC-FT		168.	212.	219.	219.
THOUS CU M		208.	262.	271.	271.

0.3 PMF

SUBJECT Dam Safety Inspection
Lebanon Dam No. 1
BY DJS DATE 8-13-80
CHKD. BY DLB DATE 2-14-80
PROJ. NO. 79-203-545
SHEET NO. 6 OF 7

GAI CONSULTANTS, INC.
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PEAK OUTFLOW IS 889. AT TIME 41.83 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	889.	578.	180.	93.	26703.
CMS	25.	16.	5.	3.	756.
INCHES		8.96	11.16	11.53	11.53
MM		227.52	283.53	292.98	292.98
AC-FT		286.	357.	369.	369.
THOUS CU M		353.	440.	455.	455.

LEBANON DAM NO.2 OUTFLOW HYDROGRAPHS

0.5 PMF

PEAK OUTFLOW IS 1780. AT TIME 41.83 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1780.	1190.	363.	188.	54039.
CMS	50.	34.	10.	5.	1530.
INCHES		18.45	22.53	23.27	23.27
MM		468.70	572.15	591.13	591.13
AC-FT		590.	720.	744.	744.
THOUS CU M		728.	889.	918.	918.

PMF

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SUB-AREA RUNOFF COMPUTATION

RESERVOIR INFLOW - LEBANON DAM NO. 1 RESERVOIR

	ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
AN =1		0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	.60	0.00	1.20	0.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	23.20	113.00	123.00	132.00	143.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .800

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.05	0.00	0.00

UNIT HYDROGRAPH DATA

TP= 3.47 CP= .82 NTA= 0

RECESSION DATA

STRTQ= -1.50 QRCSN= -.05 RTIOR= 2.00

APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNIDER CP AND TP ARE TC=28.07 AND R= 7.96 INTERVALS

UNIT HYDROGRAPH 59 END-OF-PERIOD ORDINATES, LAG= 3.44 HOURS, CP= .81 VOL= 1.00

1.	5.	10.	15.	21.	28.	34.	40.	47.	53.
59.	65.	71.	77.	82.	86.	90.	92.	94.	96.
94.	94.	92.	90.	87.	84.	79.	74.	67.	59.
54.	46.	40.	36.	31.	28.	24.	21.	19.	17.
15.	13.	11.	10.	9.	8.	7.	6.	5.	5.
4.	4.	3.	3.	3.	2.	2.	2.	2.	

SUBJECT Dam Safety Inspection

Lebanon Dam No. 1

BY DJS DATE 2-12-80

CHKD. BY DLB DATE 2-14-80 PROJ. NO. 79-303-595

SHEET NO. D OF V

						END-OF-PERIOD FLOW						
NO.	HR.MN	PERIOD	RAIN	EXCS	LOSS	CUMP Q	NO.	HR.MN	PERIOD	RAIN	EXCS	LOSS	CUMP Q
									SUM	26.54	24.13	2.41	54229.
										(674.)(	613.)(	61.)(	1535.59)

LOCAL INFLOW HYDROGRAPHS, LEBANON DAM NO. 1 RESERVOIR

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME	
CFS	147.	112.	36.	19.	5416.	
CMS	4.	3.	1.	1.	153.	
INCHES		1.73	2.25	2.33	2.33	0.1 PMF
MM		43.93	57.18	59.24	59.24	
AC-FT		55.	72.	75.	75.	
THOUS CU M		68.	89.	92.	92.	
	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME	
CFS	294.	223.	73.	38.	10832.	
CMS	8.	6.	2.	1.	307.	
INCHES		3.46	4.50	4.66	4.66	
MM		87.86	114.37	118.49	118.49	0.2 PMF
AC-FT		111.	144.	149.	149.	
THOUS CU M		136.	178.	184.	184.	
	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME	
CFS	442.	335.	109.	56.	16248.	
CMS	13.	9.	3.	2.	460.	
INCHES		5.19	6.75	7.00	7.00	
MM		131.79	171.35	177.73	177.73	0.3 PMF
AC-FT		166.	216.	224.	224.	
THOUS CU M		205.	266.	276.	276.	
	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME	
CFS	736.	558.	182.	94.	27079.	
CMS	21.	16.	5.	3.	767.	
INCHES		8.65	11.26	11.66	11.66	
MM		219.66	285.92	296.22	296.22	0.5 PMF
AC-FT		277.	360.	373.	373.	
THOUS CU M		341.	444.	460.	460.	
	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME	
CFS	1472.	1116.	363.	188.	54158.	
CMS	42.	32.	10.	5.	1534.	
INCHES		17.30	22.51	23.32	23.32	
MM		439.32	571.84	592.43	592.43	PMF
AC-FT		553.	720.	746.	746.	
THOUS CU M		682.	888.	920.	920.	

SUBJECT Dam Safety Inspection

Lebanon Dam No. 1

BY DSS DATE 8-12-80 PROJ. NO. 78-303-595

CHKD. BY DLB DATE 2-14-80 SHEET NO. E OF V

GAI CONSULTANTS, INC.

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PROJECT Dam Safety Inspection

(Lebanon Dam No. 1)

BY DJS DATE 2-13-80 PROJ. NO. 79-203-595

CHKD. BY DLB DATE 2-14-80 SHEET NO. F OF V

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********** ********** ********** ********** **********

COMBINE HYDROGRAPHS

COMBINE RESERVOIR #2 ROUTED HYDROGRAPH WITH RES. #1 INFLOW HYDROGRAPH

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
1	2	0	0	0	0	1	0	0

0.1 PMF

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	298.	219.	71.	37.	10603.
CMS	8.	6.	2.	1.	300.
INCHES		1.70	2.21	2.28	2.28
MM		43.10	56.02	57.99	57.99
AC-FT		109.	141.	146.	146.
THOUS CU M		134.	174.	180.	180.

SUM OF LEBANON DAM NO.1 INFLOW HYDROGRAPH AND LEBANON DAM NO.2 OUTFLOW HYDROGRAPH.

0.2 PMF

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	611.	445.	143.	74.	21362.
CMS	17.	13.	4.	2.	605.
INCHES		3.45	4.44	4.60	4.60
MM		87.69	112.89	116.84	116.84
AC-FT		221.	284.	294.	294.
THOUS CU M		272.	351.	363.	363.

0.3 PMF

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	955.	674.	216.	112.	32181.
CMS	27.	19.	6.	3.	911.
INCHES		5.23	6.70	6.93	6.93
MM		132.78	170.09	176.01	176.01
AC-FT		334.	428.	443.	443.
THOUS CU M		412.	528.	547.	547.

0.5 PMF

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1591.	1134.	362.	187.	53863.
CMS	45.	32.	10.	5.	1525.
INCHES		8.79	11.21	11.60	11.60
MM		223.28	284.72	294.60	294.60
AC-FT		562.	717.	742.	742.
THOUS CU M		694.	884.	915.	915.

PMF

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	3176.	2279.	726.	376.	108198.
CMS	90.	65.	21.	11.	3064.
INCHES		17.67	22.52	23.30	23.30
MM		448.74	571.99	591.78	591.78
AC-FT		1130.	1441.	1490.	1490.
THOUS CU M		1394.	1777.	1838.	1838.

PROJECT Dam Safety Inspection

Lebanon Dam No. 1

BY DJS DATE 9-19-80 PROJ. NO. 19-803-595

CHKD. BY DLB DATE 2-14-80 SHEET NO. 6 OF V

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HYDROGRAPH ROUTING

ROUTE TOTAL HYDROGRAPH THROUGH RESERVOIR #1

ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
AM =1	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSMK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-623.	-1

STAGE	622.50	623.00	624.00	625.00	625.30	626.00	626.70	626.90	627.00	627.3
	627.60	628.00	629.00	630.00	631.00	632.00	633.00	635.00		
FLOW	0.00	10.00	150.00	390.00	470.00	770.00	1270.00	1380.00	1500.00	1960.0
	2500.00	3910.00	8380.00	14400.00	20930.00	29360.00	38160.00	58510.00		
SURFACE AREA=	0.	9.	11.	24.						
CAPACITY=	0.	55.	82.	331.						
ELEVATION=	603.	623.	625.	640.						

CHEL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
622.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
625.3	0.0	0.0	0.

PEAK OUTFLOW IS 289. AT TIME 43.17 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	289.	214.	68.	35.	10042.
CMS	8.	6.	2.	1.	284.
INCHES		1.66	2.12	2.16	2.16
MM		42.05	53.90	54.93	54.93
AC-FT		106.	136.	138.	138.
THOUS CU M		131.	167.	171.	171.

0.1 PMF

LEBANON DAM NO. 1 OUTFLOW HYDROGRAPHS

PEAK OUTFLOW IS 603. AT TIME 43.00 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	603.	440.	140.	72.	20604.
CMS	17.	12.	4.	2.	583.
INCHES		3.41	4.35	4.44	4.44
MM		86.56	110.38	112.69	112.69
AC-FT		218.	278.	284.	284.
THOUS CU M		269.	343.	350.	350.

0.2 PMF

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PEAK OUTFLOW IS 948. AT TIME 42.50 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	948.	667.	212.	109.	31278.
CMS	27.	19.	6.	3.	886.
INCHES		5.17	6.57	6.74	6.74
MM		131.32	166.91	171.07	171.07
AC-FT		331.	420.	431.	431.
THOUS CU M		408.	518.	531.	531.

0.3 PMF

LEBANON DAM NO.1 OUTFLOW HYDROGRAPHS

PEAK OUTFLOW IS 1588. AT TIME 42.33 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1588.	1128.	356.	183.	52752.
CMS	45.	32.	10.	5.	1494.
INCHES		8.74	11.05	11.36	11.36
MM		222.07	280.59	288.52	288.52
AC-FT		559.	707.	727.	727.
THOUS CU M		690.	872.	896.	896.

0.5PMF

PEAK OUTFLOW IS 3173. AT TIME 42.17 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	3173.	2274.	719.	370.	106658.
CMS	90.	64.	20.	10.	3020.
INCHES		17.63	22.28	22.97	22.97
MM		447.71	565.96	583.36	583.36
AC-FT		1128.	1425.	1469.	1469.
THOUS CU M		1391.	1758.	1812.	1812.

PMF

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HYDROGRAPH ROUTING

ROUTE FROM DAM NO. 1 TO SECTION 2: 2700 FT D.S. OF DAM

ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
JO2	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTOL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-1.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELMVT	ELMAX	RLNTH	SEL
.0500	.0450	.0500	541.0	560.0	2700.	.01500

SUBJECT Dam Safety Inspection

Lebanon Dam No.1

BY DJS DATE 2-13-80 PROJ. NO. 79-303-595

CHKD. BY DLB DATE 2-14-80 SHEET NO. 4 OF 4

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CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC
0.00 560.00 1300.00 545.00 1598.00 543.00 1600.00 541.00 1605.00 541.00
1607.00 543.00 1950.00 552.00 2300.00 560.00

STORAGE	0.00	.37	.87	7.22	25.18	52.80	88.15	131.24	182.07
	306.91	380.94	462.87	552.89	650.99	757.18	871.45	993.80	1124.24
OUTFLOW	0.00	20.38	68.10	370.86	1635.83	4502.22	9051.62	15516.42	24125.85
	48655.53	64994.22	84167.55	106563.66	132380.86	161812.18	195045.79	232265.39	273650.61
STAGE	541.00	542.00	543.00	544.00	545.00	546.00	547.00	548.00	549.00
	551.00	552.00	553.00	554.00	555.00	556.00	557.00	558.00	559.00
FLOW	0.00	20.38	68.10	370.86	1635.83	4502.22	9051.62	15516.42	24125.85
	48655.53	64994.22	84167.55	106563.66	132380.86	161812.18	195045.79	232265.39	273650.61

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HYDROGRAPH ROUTING

ROUTE FROM SECTION 2 TO SECTION 3: 4550 FT D.S. OF DAM

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
203	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-1.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELMVI	ELMAX	RLNTH	SEL
.0550	.0450	.0550	527.0	560.0	1850.	.00900

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC
0.00 560.00 200.00 540.00 1397.00 530.00 1400.00 527.00 1410.00 527.00
1450.00 536.00 2100.00 540.00 2600.00 560.00

STORAGE	0.00	1.03	3.23	17.20	46.98	92.55	153.93	240.26	374.31	
	668.20	821.87	980.03	1142.67	1309.79	1481.40	1657.49	1838.07	4023.13	
OUTFLOW	0.00	90.30	354.76	1590.96	5210.97	12293.62	23759.54	41029.10	70791.89	
	166264.13	227546.07	297307.48	375317.53	461422.45	555520.41	657546.55	767463.37	885254.20	1
STAGE	527.00	528.74	530.47	532.21	533.95	535.68	537.42	539.16	540.89	
	544.37	546.11	547.84	549.58	551.32	553.05	554.79	556.53	558.26	
FLOW	0.00	90.30	354.76	1590.96	5210.97	12293.62	23759.54	41029.10	70791.89	
	166264.13	227546.07	297307.48	375317.53	461422.45	555520.41	657546.55	767463.37	885254.20	1

SUBJECT Dam Safety Inspection

Lebanon Dam No. 1

BY DJS DATE 8-13-80 PROJ. NO. 79-303-595

CHKD. BY DLB DATE 2-14-80 SHEET NO. 5 OF 14

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HYDROGRAPH ROUTING

ROUTE FROM SECTION 3 TO SECTION 4: 6050 FT D.S. OF DAM

ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
304	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP		LSTR
0.0	0.000	0.00	1	1	0	0		0
	NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
	1	0	0	0.000	0.000	0.000	-1.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNV1	ELMAX	RLNTH	SEL
.0550	.0450	.0550	516.0	540.0	1500.	.00500

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

0.00 540.00 200.00 524.00 977.00 519.00 980.00 516.00 990.00 516.00
993.00 519.00 1200.00 523.00 2150.00 540.00

STORAGE	0.00	.49	1.09	4.00	17.50	42.38	78.67	124.79	175.10
	286.99	348.58	413.92	483.01	555.87	632.48	712.85	796.97	884.86
OUTFLOW	0.00	34.37	111.48	306.30	1266.32	3684.05	8092.74	15649.05	26095.54
	54469.12	72424.89	92942.85	116072.54	141869.27	170392.27	201703.44	235866.58	272946.75
STAGE	516.00	517.26	518.53	519.79	521.05	522.32	523.58	524.84	526.11
	528.63	529.89	531.16	532.42	533.68	534.95	536.21	537.47	538.74
FLOW	0.00	34.37	111.48	306.30	1266.32	3684.05	8092.74	15649.05	26095.54
	54469.12	72424.89	92942.85	116072.54	141869.27	170392.27	201703.44	235866.58	272946.75

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HYDROGRAPH ROUTING

ROUTE FROM SECTION 4 TO SECTION 5: 8650 FT D.S. OF DAM

ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
405	0	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP		LSTR
0.0	0.000	0.00	1	1	0	0		0
	NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
	1	0	0	0.000	0.000	0.000	-1.	0

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NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.0550	.0450	.0550	499.0	540.0	2600.	.00600

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC
0.00 540.00 170.00 520.00 647.00 502.00 650.00 499.00 660.00 499.00
663.00 502.00 1050.00 520.00 1550.00 540.00

STORAGE	0.00	1.57	6.06	22.93	53.14	96.69	153.57	223.80	307.38
	514.39	634.89	764.70	903.82	1052.25	1209.99	1377.04	1553.41	1739.06
OUTFLOW	0.00	93.16	403.76	1597.82	4392.97	9355.93	16982.80	27725.65	42005.17
	83194.74	111976.71	145457.45	183786.00	227121.57	275629.28	329477.58	388836.72	453877.67
STAGE	499.00	501.16	503.32	505.47	507.63	509.79	511.95	514.11	516.26
	520.58	522.74	524.89	527.05	529.21	531.37	533.53	535.68	537.84
FLOW	0.00	93.16	403.76	1597.82	4392.97	9355.93	16982.80	27725.65	42005.17
	83194.74	111976.71	145457.45	183786.00	227121.57	275629.28	329477.58	388836.72	453877.67

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HYDROGRAPH ROUTING

ROUTE FROM SECTION 5 TO SECTION 6: 13550 FT D.S. OF DAM

ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
506	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NORMAL DEPTH CHANNEL ROUTING

NSTPS	NSTDL	LAG	AMSAK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-1.	0

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.0550	.0450	.0550	472.0	500.0	4900.	.00400

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC
0.00 500.00 400.00 480.00 597.00 475.00 600.00 472.00 610.00 472.00
613.00 475.00 950.00 480.00 1150.00 500.00

STORAGE	0.00	1.90	4.29	19.07	59.93	126.80	216.85	315.08	422.24
	656.94	785.28	920.95	1063.95	1214.28	1371.94	1536.93	1709.24	1888.89
OUTFLOW	0.00	39.84	130.26	435.96	1476.13	3682.72	7725.95	13560.72	20878.79
	39940.69	51714.47	65017.95	79883.19	96345.16	114440.82	134208.49	155687.42	178917.44
STAGE	472.00	473.47	474.95	476.42	477.89	479.37	480.84	482.32	483.79
	486.74	488.21	489.68	491.16	492.63	494.11	495.58	497.05	498.53
FLOW	0.00	39.84	130.26	435.96	1476.13	3682.72	7725.95	13560.72	20878.79
	39940.69	51714.47	65017.95	79883.19	96345.16	114440.82	134208.49	155687.42	178917.44

SUBJECT Dam Safety Inspection

BY DJS DATE 9-13-80 PROJ. NO. 79-803-515

CHKD. BY DLB DATE 2-14-80 SHEET NO. 6 OF V

Lebanon Dam No. 1

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SUMMARY OF DAM SAFETY ANALYSIS

LEBANON DAM NO. 2; OVERTOPPING OCCURS AT APPROXIMATELY 0.21 PMF.

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	676.00	676.00	679.80
STORAGE	150.	150.	186.
OUTFLOW	0.	0.	340.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.10	678.19	0.00	170.	151.	0.00	42.67	0.00
.20	679.61	0.00	184.	317.	0.00	42.67	0.00
.21 *	679.80	—	186.	340.	—	—	—
.30	680.08	.28	189.	533.	2.50	41.83	0.00
.50	680.30	.50	191.	889.	4.50	41.83	0.00
1.00	680.68	.88	195.	1780.	6.50	41.83	0.00

* INTERPOLATED VALUES; OVERTOPPING OCCURS @ APPROXIMATELY 0.21 PMF.

LEBANON DAM NO. 1; OVERTOPPING OCCURS AT APPROXIMATELY 0.16 PMF.

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	622.50	622.50	625.30
STORAGE	55.	55.	82.
OUTFLOW	0.	0.	470.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.10	624.58	0.00	75.	269.	0.00	43.17	0.00
.16 **	625.30	—	82.	470.	—	—	—
.20	625.61	.31	86.	603.	2.67	43.00	0.00
.30	626.25	.95	93.	946.	4.50	42.50	0.00
.50	627.06	1.76	103.	1588.	6.33	42.33	0.00
1.00	627.79	2.49	112.	3173.	8.50	42.17	0.00

** INTERPOLATED VALUES; OVERTOPPING OCCURS @ APPROXIMATELY 0.16 PMF

PLAN 1 STATION 102

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.10	287.	543.7	43.50
.20	600.	544.2	43.17
.30	943.	544.5	42.67
.50	1582.	545.0	42.50
1.00	3169.	545.5	42.33

PLAN 1 STATION 203

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.10	286.	530.0	43.67
.20	599.	530.8	43.33
.30	940.	531.3	42.67
.50	1577.	532.2	42.67
1.00	3163.	533.0	42.50

PLAN 1 STATION 304

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.10	285.	519.7	43.83
.20	596.	520.2	43.50
.30	935.	520.6	43.00
.50	1573.	521.2	42.67
1.00	3157.	522.0	42.50

PLAN 1 STATION 405

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.10	284.	502.5	44.00
.20	594.	503.7	43.67
.30	930.	504.3	43.17
.50	1566.	505.4	42.83
1.00	3151.	506.7	42.67

PLAN 1 STATION 506

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.10	274.	475.6	44.50
.20	576.	476.6	44.17
.30	894.	477.1	43.67
.50	1522.	477.9	43.33
1.00	3095.	479.0	43.00

SECTION 2, APPROXIMATELY 2700 FT DOWNSTREAM FROM LEBANON DAM NO. 1

SECTION 3, APPROXIMATELY 4550 FT D.S. FROM LEBANON DAM NO. 1

SECTION 4, APPROXIMATELY 6050 FT D.S. FROM LEBANON DAM NO. 1

SECTION 5, APPROXIMATELY 8650 FT D.S. FROM LEBANON DAM NO. 1

SECTION 6, APPROXIMATELY 13,550 FT D.S. FROM LEBANON DAM NO. 1

SUBJECT Dam Safety Inspection

Lebanon Dam No. 1

BY DJS DATE 2-13-80 PROJ. NO. 79-303-595

CHKD. BY DLB DATE 2-14-80 SHEET NO. M OF V

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PROJECT Dam Safety Inspection (Lebanon Dam No. 1)
BY DTS DATE 2-13-80 PROJ. NO. 79-303-595
CHKD. BY DWB DATE 2-14-80 SHEET NO. N OF N

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BREACHING ANALYSIS

(SAME INPUT DATA AS FOR OVERTOPPING ANALYSIS, WITH THE ADDITION OF BREACH CONDITIONS GIVEN HERE.)

LEBANON DAM NO. 2

PLAN

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DAM SAFETY INSPECTION
LEBANON DAM #1 W/U.S. LEBANON DAM #2 **** BREACHING ANALYSIS ****
10-MINUTE TIME STEP AND 48-HOUR STORM DURATION

**********          **********          **********          **********          **********

                              HYDROGRAPH ROUTING

     ROUTE THROUGH RESERVOIR - LEBANON DAM NO. 2

                                   DAM DATA
                          TOPEL     COOD      EXPO     DAMWID
                          679.8      0.0       0.0        0.

                                DAM BREACH DATA
                BRWID       Z     ELBM     TFAIL     WSEL   FAILEL
                  0.      .50   640.00       .50   676.00   679.80

(1)                        STATION AM #2 . PLAN 1, RATIO 1

BEGIN DAM FAILURE AT 41.83 HOURS

 PEAK OUTFLOW IS     5987. AT TIME  42.33 HOURS


                                DAM BREACH DATA
                BRWID       Z     ELBM     TFAIL     WSEL   FAILEL
                 300.    5.00   640.00       .50   676.00   679.80

(2)                        STATION AM #2 . PLAN 2, RATIO 1

BEGIN DAM FAILURE AT 41.83 HOURS

 PEAK OUTFLOW IS     8125. AT TIME  42.00 HOURS


                                DAM BREACH DATA
                BRWID       Z     ELBM     TFAIL     WSEL   FAILEL
                  0.      .50   640.00      4.00   676.00   679.80

(3)                        STATION AM #2 . PLAN 3, RATIO 1

BEGIN DAM FAILURE AT 41.83 HOURS

 PEAK OUTFLOW IS     1074. AT TIME  44.33 HOURS
```

ECT Dam Safety Inspection

Lebanon Dam No. 1

BY DJS DATE 2-12-80 PROJ. NO. 79-203-595

CHKD. BY DLB DATE 2-14-80 SHEET NO. O OF V

CONSULTANTS, INC.
Engineers • Geologists • Planners
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PLAN

DAM BREACH DATA

BRWID	Z	ELBM	TFAIL	WSEL	FAILEL
300.	5.00	640.00	4.00	676.00	679.80

STATION AM =2 , PLAN 4, RATIO 1

(4) BEGIN DAM FAILURE AT 41.83 HOURS

PEAK OUTFLOW IS 1512. AT TIME 42.17 HOURS

DAM BREACH DATA

BRWID	Z	ELBM	TFAIL	WSEL	FAILEL
100.	1.00	640.00	2.00	676.00	679.80

STATION AM =2 , PLAN 5, RATIO 1

(5) BEGIN DAM FAILURE AT 41.83 HOURS

PEAK OUTFLOW IS 2338. AT TIME 42.29 HOURS

AD-A085 227 GAI CONSULTANTS INC MONROEVILLE PA F/6 13/13
NATIONAL DAM INSPECTION REPORT. LEBANON RESERVOIR DAM NUMBER 1.--ETC(U)
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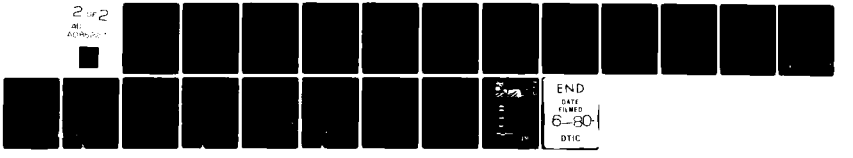

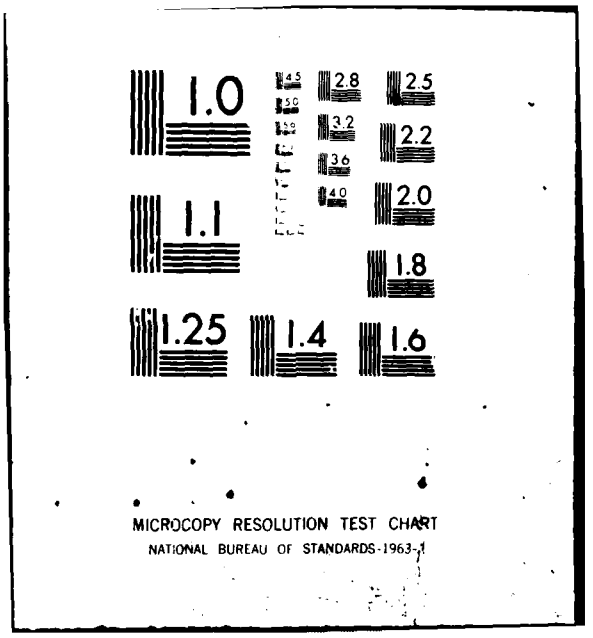
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

PLAN
(2)

THE DAM BREACH HYDROGRAPH WAS DEVELOPED USING A TIME INTERVAL OF .010 HOURS DURING BREACH FORMATION.
DOWNSTREAM CALCULATIONS WILL USE A TIME INTERVAL OF .167 HOURS.
THIS TABLE COMPARES THE HYDROGRAPH FOR DOWNSTREAM CALCULATIONS WITH THE COMPUTED BREACH HYDROGRAPH.
INTERMEDIATE FLOWS ARE INTERPOLATED FROM END-OF-PERIOD VALUES.

TIME (HOURS)	TIME FROM BEGINNING OF BREACH (HOURS)	INTERPOLATED BREACH HYDROGRAPH (CFS)	-	COMPUTED BREACH HYDROGRAPH (CFS)	=	ERROR (CFS)	ACCUMULATED ERROR (CFS)	ACCUMULATED ERROR (AC-FT)
41.833	0.000	377.		377.		0.	0.	0.
41.843	.010	833.		1036.		-203.	-203.	-0.
41.853	.020	1289.		2063.		-775.	-978.	-1.
41.863	.029	1744.		3203.		-1459.	-2436.	-2.
41.873	.039	2200.		4311.		-2111.	-4548.	-4.
41.882	.049	2656.		5319.		-2663.	-7211.	-6.
41.892	.059	3112.		6198.		-3086.	-10297.	-8.
41.902	.069	3567.		6936.		-3369.	-13665.	-11.
41.912	.078	4023.		7394.		-3371.	-17037.	-14.
41.922	.088	4479.		7757.		-3278.	-20315.	-16.
41.931	.098	4935.		8049.		-3114.	-23429.	-19.
41.941	.108	5391.		8095.		-2704.	-26133.	-21.
41.951	.118	5846.		8104.		-2258.	-28391.	-23.
41.961	.127	6302.		8111.		-1809.	-30201.	-24.
41.971	.137	6758.		8117.		-1359.	-31559.	-26.
41.980	.147	7214.		8120.		-907.	-32466.	-26.
41.990	.157	7669.		8123.		-454.	-32920.	-27.
42.000	.167	8125.		8125.		-0.	-32920.	-27.
42.010	.176	7907.		8053.		-146.	-33066.	-27.
42.020	.186	7689.		7655.		35.	-33032.	-27.
42.029	.196	7471.		7385.		87.	-32945.	-27.
42.039	.206	7254.		7200.		54.	-32891.	-27.
42.049	.216	7036.		7072.		-37.	-32928.	-27.
42.059	.225	6818.		6984.		-166.	-33094.	-27.
42.069	.235	6600.		6806.		-206.	-33300.	-27.
42.078	.245	6382.		6391.		-9.	-33309.	-27.
42.088	.255	6164.		6126.		38.	-33271.	-27.
42.098	.265	5946.		5954.		-8.	-33279.	-27.
42.108	.275	5728.		5842.		-113.	-33392.	-27.
42.118	.284	5511.		5768.		-257.	-33649.	-27.
42.127	.294	5293.		5472.		-180.	-33829.	-27.
42.137	.304	5075.		4972.		103.	-33726.	-27.
42.147	.314	4857.		4687.		170.	-33556.	-27.
42.157	.324	4639.		4520.		119.	-33437.	-27.
42.167	.333	4421.		4421.		0.	-33437.	-27.
42.176	.343	4197.		4362.		-165.	-33602.	-27.
42.186	.353	3973.		3900.		74.	-33528.	-27.
42.196	.363	3749.		3508.		441.	-33087.	-27.
42.206	.373	3525.		3316.		209.	-33078.	-27.
42.216	.382	3301.		3218.		83.	-32995.	-27.
42.225	.392	3077.		3168.		-91.	-33085.	-27.
42.235	.402	2853.		3141.		-288.	-33373.	-27.
42.245	.412	2629.		2149.		480.	-32893.	-27.
42.255	.422	2405.		1880.		525.	-32368.	-26.
42.265	.431	2181.		1799.		382.	-31986.	-26.
42.275	.441	1957.		1774.		183.	-31802.	-26.
42.284	.451	1733.		1765.		-32.	-31834.	-26.
42.294	.461	1509.		945.		564.	-31270.	-25.
42.304	.471	1285.		654.		631.	-30639.	-25.
42.314	.480	1061.		665.		396.	-30042.	-24.
42.324	.490	837.		576.		261.	-29782.	-24.
42.333	.500	613.		613.		0.	-29782.	-24.

ECT Dam Safety Inspection

Lebanon Dam No. 1

BY DJS DATE 2-13-80 PROJ. NO. 79-203-595

CHKD. BY RLB DATE 2-14-80 SHEET NO. 8 OF V

GAI CONSULTANTS, INC.
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SUBJECT Dam Safety Inspection
Lebanon Dam No. 1

BY DJS DATE 2-13-80 PROJ. NO. 79-203-595

CHKD. BY DLB DATE 2-14-80 SHEET NO. Q OF V

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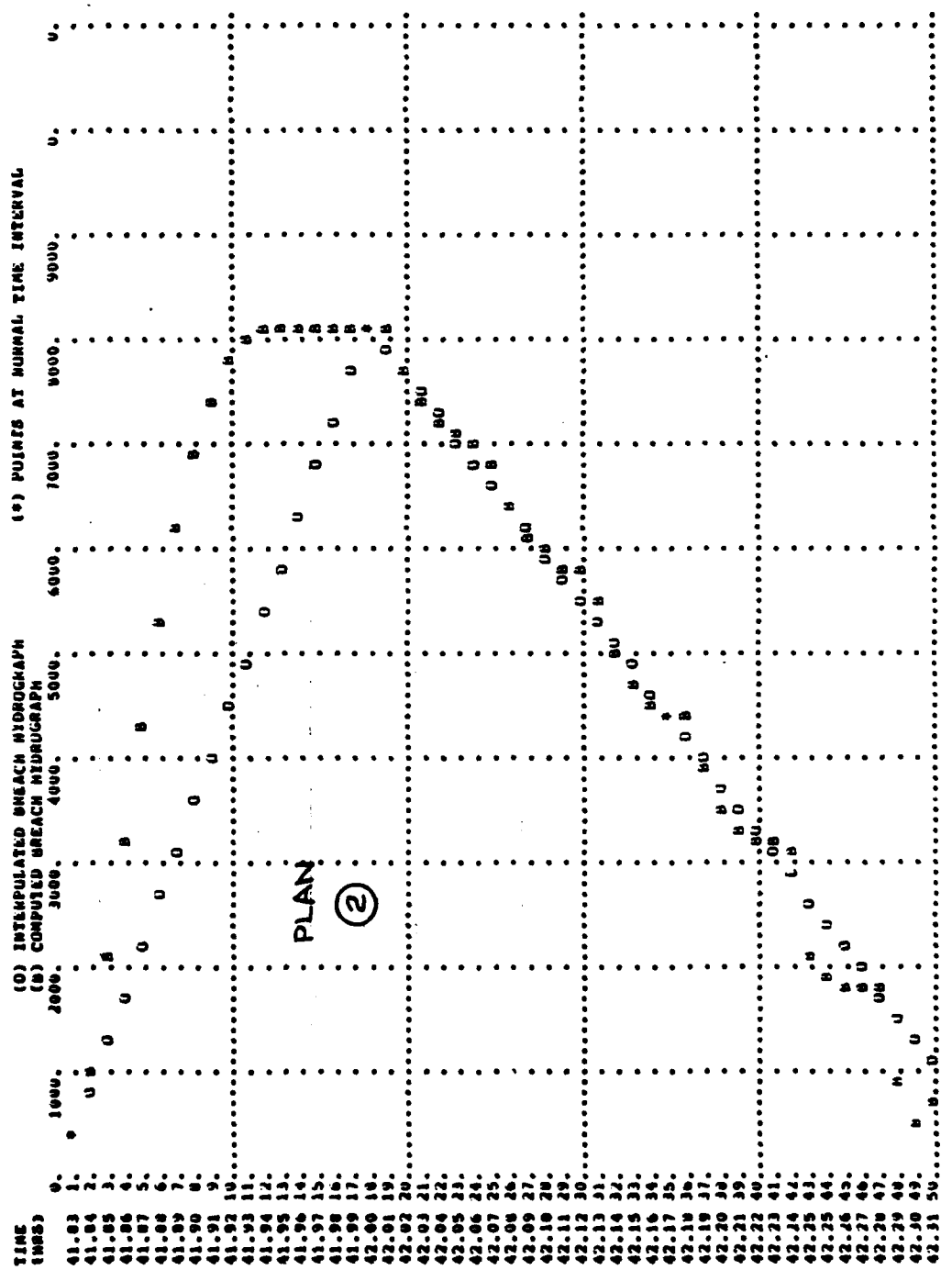

IECT DAM SAFETY INSPECTION

LEBANON DAM No. 1

BY DJS DATE 2-13-80 PROJ. NO. 79-303-595

CHKD. BY DLB DATE 2-14-80 SHEET NO. R OF V

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LEBANON
DAM NO.1

PLAN

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**********          **********          **********          **********          **********

                              HYDROGRAPH ROUTING

          ROUTE TOTAL HYDROGRAPH THROUGH RESERVOIR #1

                                            DAM BREACH DATA
                              BRWID       Z    ELBM    TFAIL      WSEL   FAILEL
                                 0.    1.00  603.00      .50    622.50   625.30

                                   STATION AM =1 , PLAN 1, RATIO 1

(1)  BEGIN DAM FAILURE AT 41.33 HOURS

        PEAK OUTFLOW IS     4333. AT TIME  42.50 HOURS

                                            DAM BREACH DATA
                              BRWID       Z    ELBM    TFAIL      WSEL   FAILEL
                               300.    8.00  603.00      .50    622.50   625.30

                                   STATION AM =1 , PLAN 2, RATIO 1

(2)  BEGIN DAM FAILURE AT 41.33 HOURS

        PEAK OUTFLOW IS     8375. AT TIME  42.00 HOURS

                                            DAM BREACH DATA
                              BRWID       Z    ELBM    TFAIL      WSEL   FAILEL
                                 0.    1.00  603.00     4.00    622.50   625.30

                                   STATION AM =1 , PLAN 3, RATIO 1

(3)  BEGIN DAM FAILURE AT 41.33 HOURS

        PEAK OUTFLOW IS     1809. AT TIME  44.50 HOURS

                                            DAM BREACH DATA
                              BRWID       Z    ELBM    TFAIL      WSEL   FAILEL
                               300.    8.00  603.00     4.00    622.50   625.30

                                   STATION AM =1 , PLAN 4, RATIO 1

(4)  BEGIN DAM FAILURE AT 41.33 HOURS

        PEAK OUTFLOW IS     2398. AT TIME  42.25 HOURS

                                            DAM BREACH DATA
                              BRWID       Z    ELBM    TFAIL      WSEL   FAILEL
                                75.    2.00  603.00     2.00    622.50   625.30

                                   STATION AM =1 , PLAN 5, RATIO 1

(5)  BEGIN DAM FAILURE AT 41.33 HOURS

        PEAK OUTFLOW IS     3518. AT TIME  42.33 HOURS
```

PROJECT Dam Safety Inspection

(Lebanon Dam No. 1)

BY DJS DATE 2-13-80 PROJ. NO. 79-303-595

CHKD. BY DLB DATE 2-14-80 SHEET NO. 5 OF 7

CONSULTANTS, INC.

Engineers • Geologists • Planners
Environmental Specialists

PLAN

(2)

THE DAM BREACH HYDROGRAPH WAS DEVELOPED USING A TIME INTERVAL OF .010 HOURS DURING BREACH FORMATION.
DOWNSTREAM CALCULATIONS WILL USE A TIME INTERVAL OF .167 HOURS.
THIS TABLE COMPARES THE HYDROGRAPH FOR DOWNSTREAM CALCULATIONS WITH THE COMPUTED BREACH HYDROGRAPH.
INTERMEDIATE FLOWS ARE INTERPOLATED FROM END-OF-PERIOD VALUES.

TIME (HOURS)	TIME FROM BEGINNING OF BREACH (HOURS)	INTERPOLATED BREACH HYDROGRAPH (CFS)		COMPUTED BREACH HYDROGRAPH (CFS)	= ERROR (CFS)	ACCUMULATED ERROR (CFS)	ACCUMULATED ERROR (AC-FT)
41.333	0.000	496.		496.	0.	0.	0.
41.343	.010	749.		791.	-42.	-42.	-0.
41.353	.020	1003.		1249.	-246.	-287.	-0.
41.363	.029	1257.		1776.	-519.	-807.	-1.
41.373	.039	1511.		2314.	-804.	-1610.	-1.
41.382	.049	1764.		2828.	-1064.	-2674.	-2.
41.392	.059	2018.		3300.	-1281.	-3956.	-3.
41.402	.069	2272.		3711.	-1439.	-5394.	-4.
41.412	.078	2526.		4054.	-1529.	-6923.	-6.
41.422	.088	2780.		4329.	-1550.	-8473.	-7.
41.431	.098	3033.		4566.	-1532.	-10005.	-8.
41.441	.108	3287.		4735.	-1448.	-11453.	-9.
41.451	.118	3541.	DUE TO	4847.	-1306.	-12759.	-10.
41.461	.127	3795.	BREACHING	4939.	-1145.	-13904.	-11.
41.471	.137	4048.	OF DAM	4980.	-932.	-14835.	-12.
41.480	.147	4302.	NO. 1 ONLY	4967.	-665.	-15501.	-13.
41.490	.157	4556.		4908.	-352.	-15853.	-13.
41.500	.167	4810.		4810.	-0.	-15853.	-13.
41.510	.176	4631.		4679.	-48.	-15901.	-13.
41.520	.186	4453.		4524.	-71.	-15971.	-13.
41.529	.196	4275.		4348.	-74.	-16045.	-13.
41.539	.206	4096.		4159.	-63.	-16108.	-13.
41.549	.216	3918.		3960.	-42.	-16150.	-13.
41.559	.225	3739.		3756.	-17.	-16167.	-13.
41.569	.235	3561.		3550.	11.	-16155.	-13.
41.578	.245	3383.		3344.	39.	-16117.	-13.
41.588	.255	3204.		3141.	63.	-16054.	-13.
41.598	.265	3026.		2943.	82.	-15971.	-13.
41.608	.275	2847.		2752.	96.	-15876.	-13.
41.618	.284	2669.		2568.	101.	-15774.	-13.
41.627	.294	2491.		2391.	99.	-15675.	-13.
41.637	.304	2312.		2224.	88.	-15587.	-13.
41.647	.314	2134.		2066.	68.	-15518.	-13.
41.657	.324	1955.		1917.	39.	-15480.	-13.
41.667	.333	1777.		1777.	0.	-15480.	-13.
41.676	.343	1714.		1647.	67.	-15413.	-12.
41.686	.353	1651.		1528.	124.	-15289.	-12.
41.696	.363	1588.		1417.	171.	-15118.	-12.
41.706	.373	1526.		1316.	209.	-14909.	-12.
41.716	.382	1463.		1224.	238.	-14671.	-12.
41.725	.392	1400.		1141.	259.	-14412.	-12.
41.735	.402	1337.		1066.	271.	-14141.	-11.
41.745	.412	1274.		999.	275.	-13865.	-11.
41.755	.422	1211.		940.	272.	-13594.	-11.
41.765	.431	1148.		888.	261.	-13333.	-11.
41.775	.441	1085.		843.	242.	-13091.	-11.
41.784	.451	1023.		805.	217.	-12874.	-10.
41.794	.461	960.		774.	185.	-12688.	-10.
41.804	.471	897.		749.	148.	-12541.	-10.
41.814	.480	834.		730.	104.	-12437.	-10.
41.824	.490	771.		716.	55.	-12382.	-10.
41.833	.500	708.		708.	0.	-12382.	-10.

PROJECT DAM SAFETY INSPECTION
LEBANON DAM No. 1

BY DSS DATE 2-13-80 PROJ. NO. 79-203-595

CHKD. BY DLB DATE 2-14-80 SHEET NO. T OF V

CONSULTANTS, INC.
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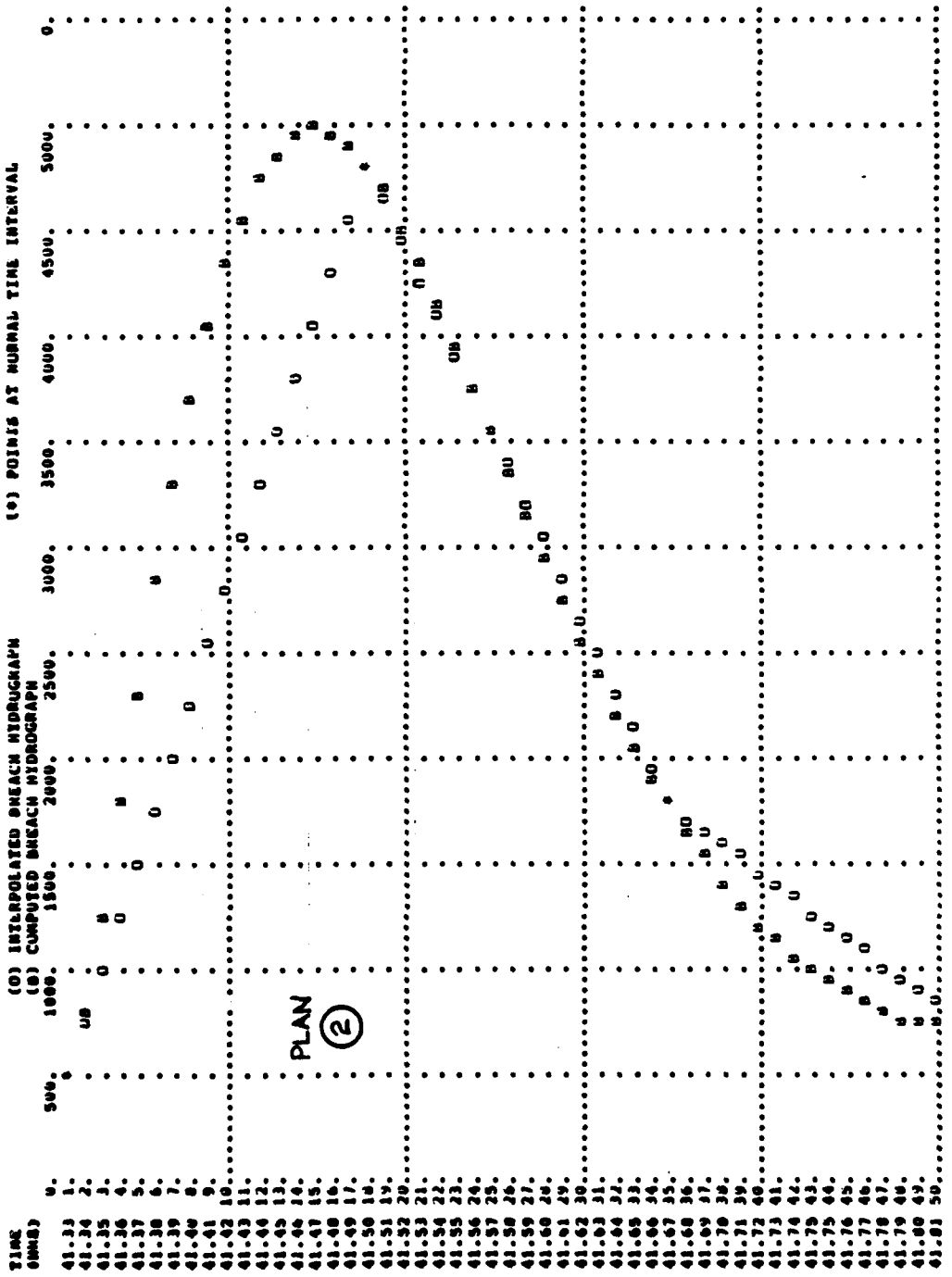

PROJECT Dam Safety Inspection

Lebanon Dam Nos 1 & 2

BY DTS DATE 2-12-80

CHKD. BY D.L.B. DATE 2-14-80

PROJ. NO. 79-203-595

SHEET NO. 1 OF 4

SUMMARY OUTPUT:

LEBANON DAM NO.2

	ELEVATION	STORAGE	OUTFLOW
INITIAL VALUE	676.00	150.	0.
SPILLWAY CREST	676.00	150.	0.
TOP OF DAM	679.00	186.	340.

PLAN	RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1	.24	679.07	.07	187.	5887.	.28	42.33	41.83
2	.24	679.05	.05	187.	8125.	.18	42.00	41.83
3	.24	679.93	.13	187.	1074.	.83	44.33	41.83
4	.24	679.05	.05	187.	1512.	.17	42.17	41.83
5	.24	679.06	.06	187.	2338.	.21	42.29	41.83

LEBANON DAM NO.1

	ELEVATION	STORAGE	OUTFLOW
INITIAL VALUE	622.50	55.	0.
SPILLWAY CREST	622.50	55.	0.
TOP OF DAM	625.50	82.	470.

	RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1	.24	625.39	.09	83.	4333.	.34	42.50	41.33
2	.24	625.34	.04	83.	8375.	.19	42.00	41.33
3	.24	625.67	.37	86.	1809.	1.83	44.50	41.33
4	.24	625.34	.04	83.	2398.	.25	42.25	41.33
5	.24	625.36	.06	83.	3518.	.25	42.33	41.33

STATION 102

	RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
1	.24	3979.	545.8	42.50
2	.24	6417.	546.4	42.17
3	.24	1793.	545.1	44.67
4	.24	2294.	545.2	42.33
5	.24	3427.	545.6	42.50

SECTION 2

CONSULTANTS, INC.
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Environmental Specialists

JECT DAM SAFETY INSPECTION
LEBANON DAM No. 1

BY DJT DATE 3-12-80 PROJ. NO. 79-202-595
CHKD. BY DLB DATE 3-14-80 SHEET NO. V OF V

GAI CONSULTANTS, INC.
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Environmental Specialists

PLAN

SECTION 3

RATIO	STATION 203 MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.24	3824.	533.3	42.67
.24	3004.	533.8	42.17
.24	1782.	532.3	44.67
.24	2273.	532.5	42.50
.24	3332.	533.0	42.67

SECTION 4

RATIO	STATION 304 MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.24	3564.	522.2	42.83
.24	4795.	522.6	42.33
.24	1772.	521.3	44.83
.24	2224.	521.6	42.67
.24	3228.	522.1	42.67

SECTION 5

RATIO	STATION 405 MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.24	3410.	506.9	42.83
.24	4194.	507.5	42.50
.24	1758.	505.6	45.00
.24	2180.	505.9	42.83
.24	3151.	506.7	42.83

SECTION 6

RATIO	STATION 506 MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.24	2870.	478.8	43.17
.24	3140.	479.0	42.67
.24	1675.	478.0	45.33
.24	1954.	478.2	43.33
.24	2688.	478.7	43.17

LIST OF REFERENCES

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APPENDIX E

FIGURES

LIST OF FIGURES

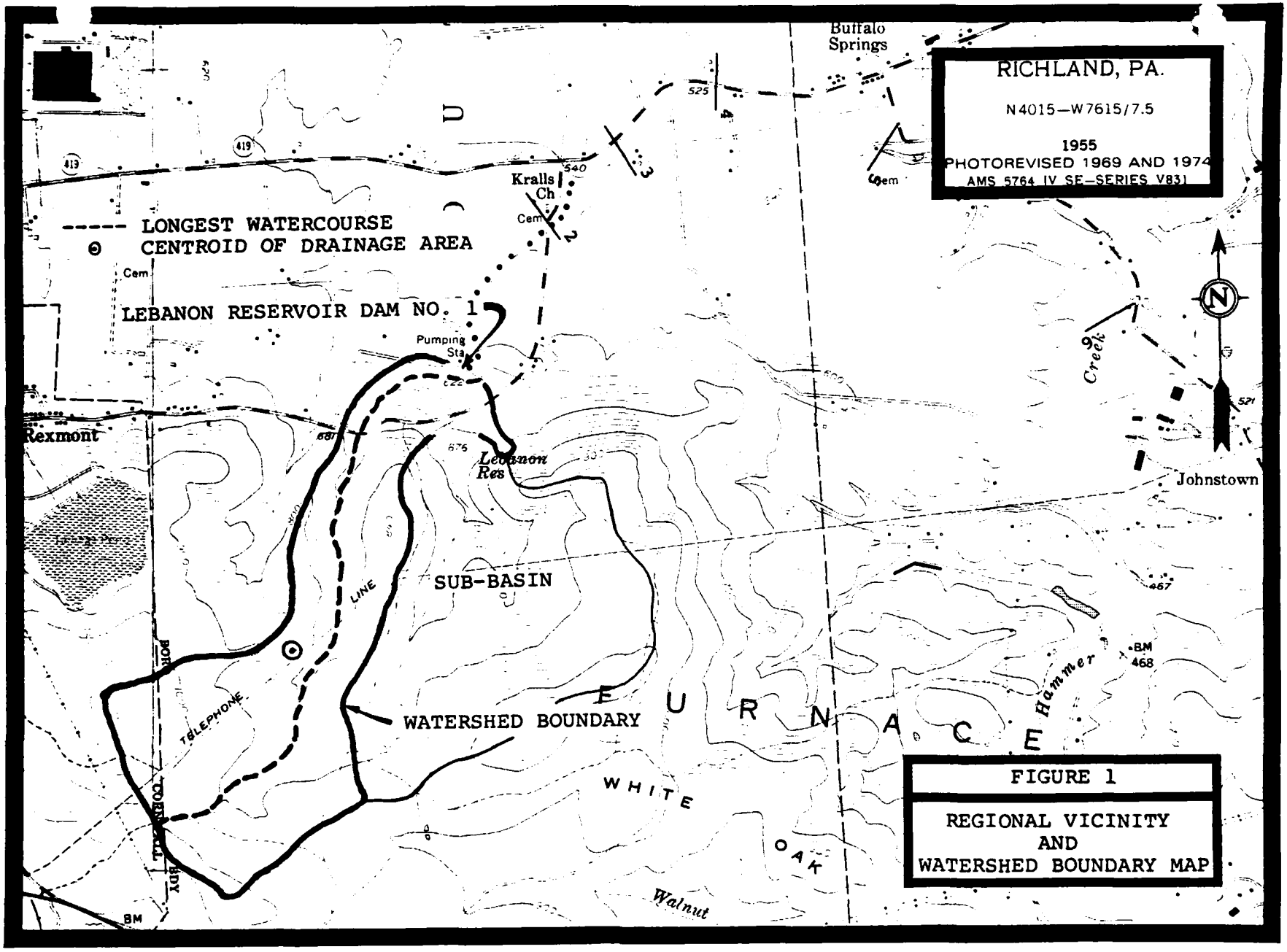
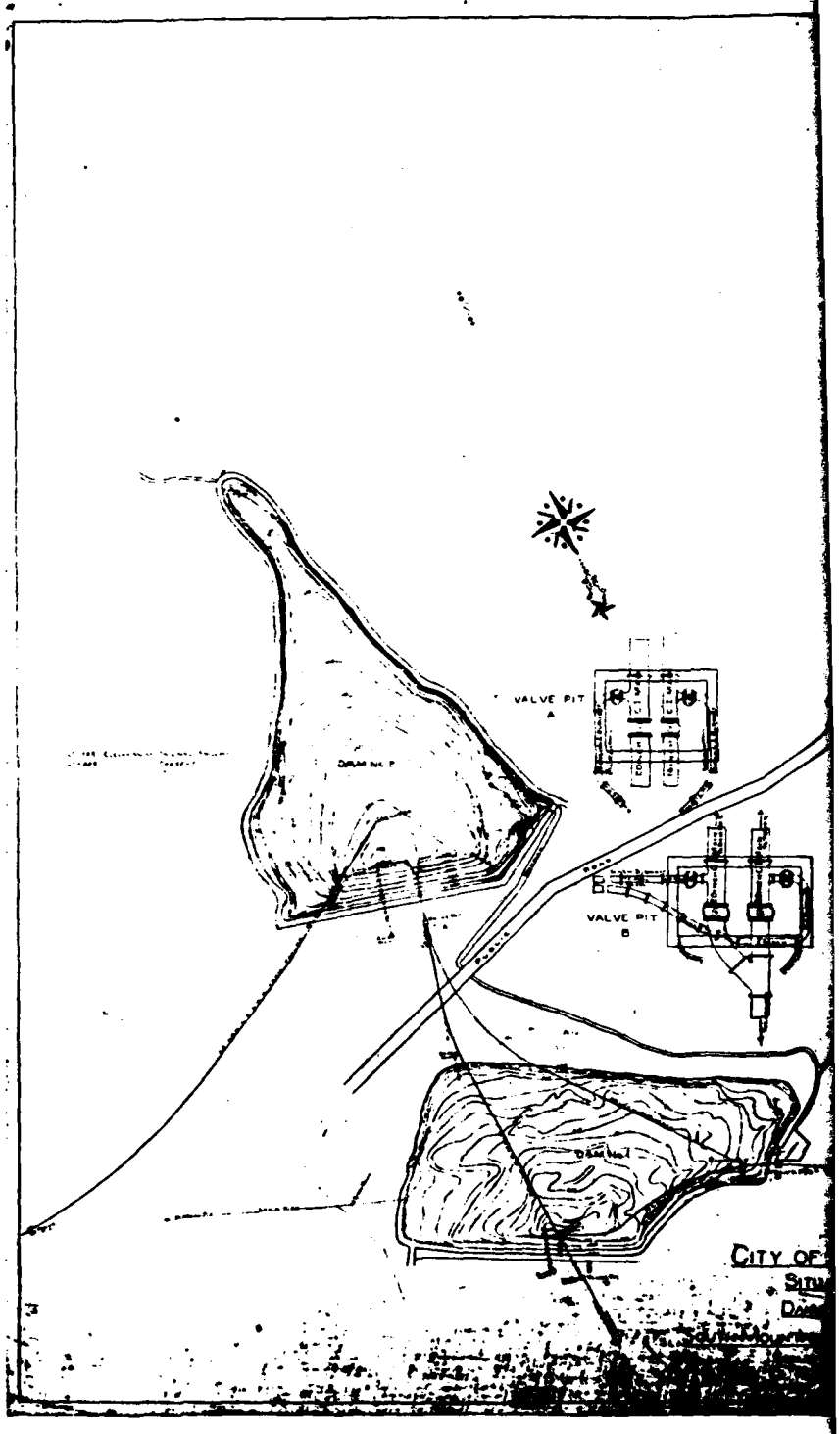


FIGURE 1

REGIONAL VICINITY
AND
WATERSHED BOUNDARY MAP


VALVE PIT
A
VALVE PIT
B
CITY OF

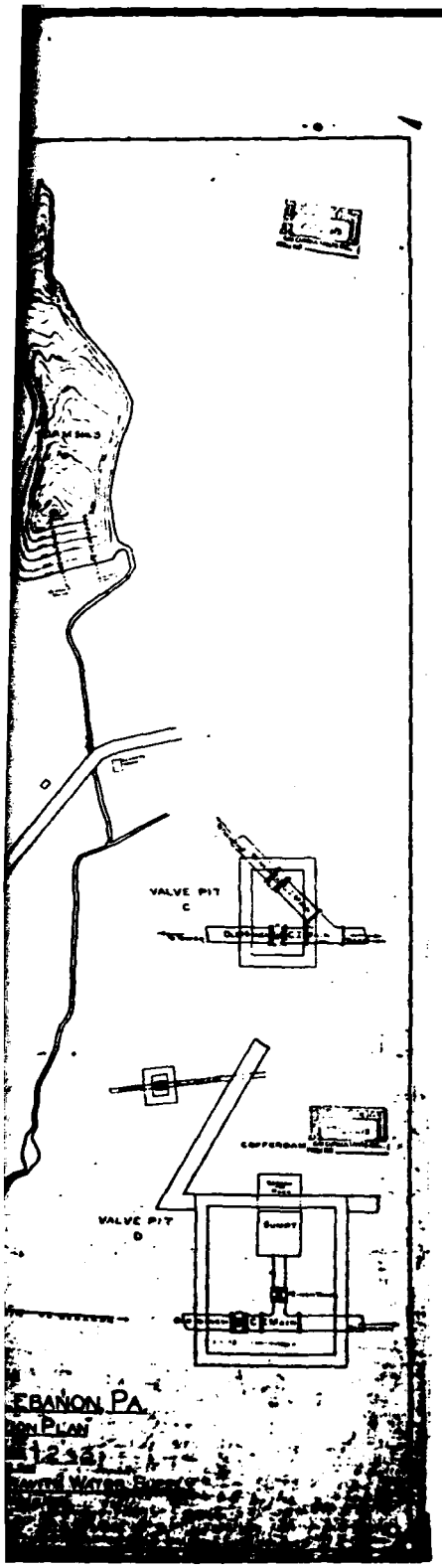


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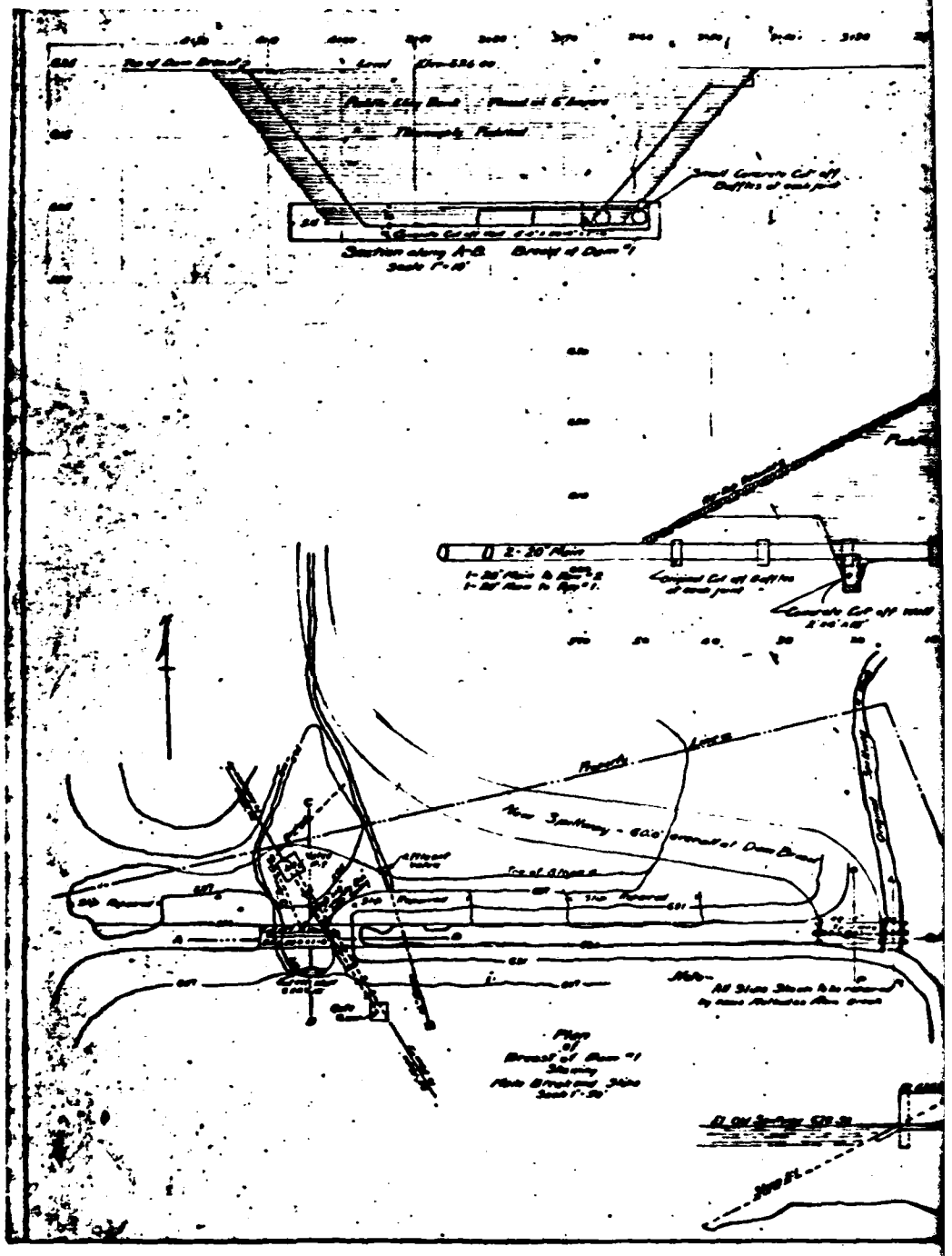
FIGURE 2



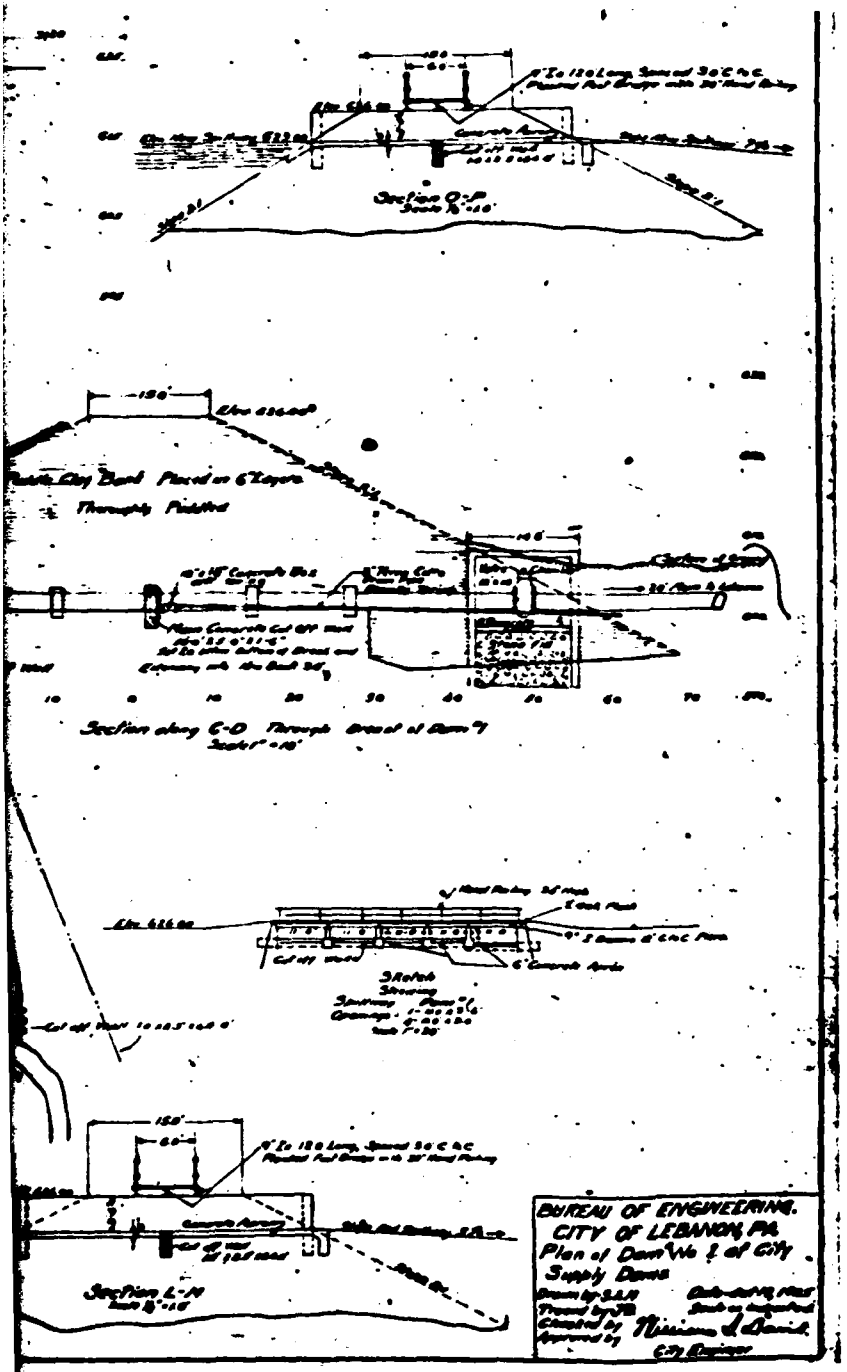


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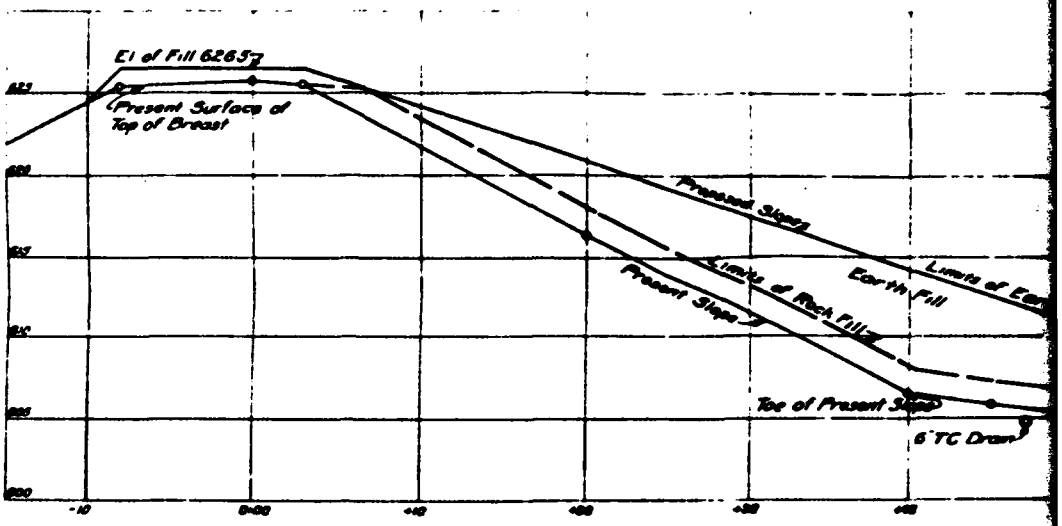
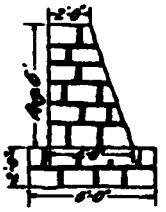
FIGURE 3



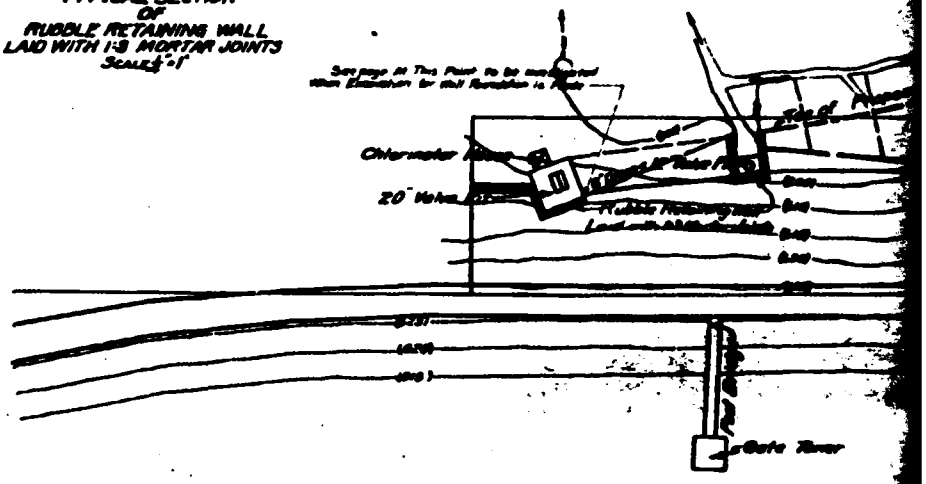
TYPICAL CROSS SECTION OF BREAST OF DAM NO. 1

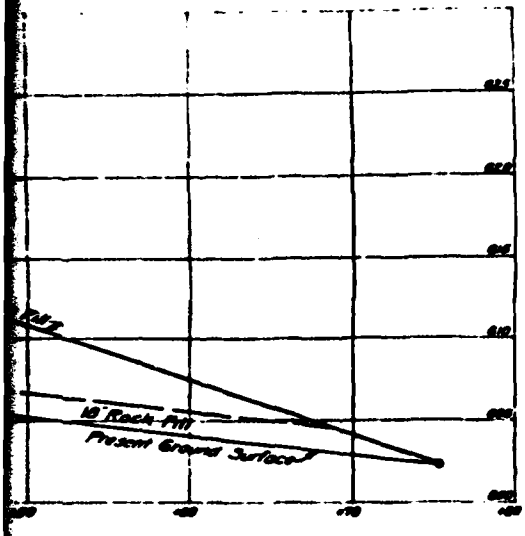
SHOWING LIMITS OF EARTH AND ROCK FILL

HOR. SCALE 1"=8'
VER. SCALE



TYPICAL SECTION OF RUBBLE RETAINING WALL LAID WITH 1:3 MORTAR JOINTS
Scale 1"=1'





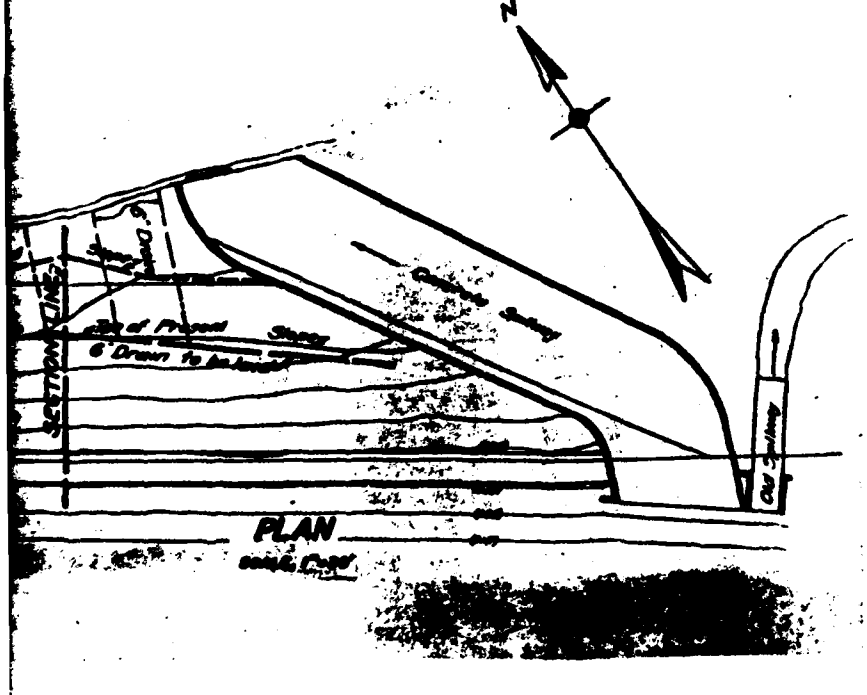


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FIGURE 4

APPENDIX F

GEOLOGY

Geology.

Lebanon Reservoir Dam No. 1 is located on the West Branch of Hammer Creek, about 6 miles southeast of the City of Lebanon, at the foot of South Mountain. The dam lies about 9 miles below the source of the West Branch of Hammer Creek, a tributary of Cacalico Creek that empties into Conestogo Creek.

Physiographically, this area is located in the Triassic Lowland Section of the Piedmont Province of eastern Pennsylvania.

Structurally, the major regional feature is a synclinorium whose longitudinal axis is generally trending northeast-southwest. "The entire south limb of the synclinorium in the Lebanon Valley appears to be overturned and essentially recumbent." The local structure of the Triassic rocks in the Richland quadrangle can be best described as a broadly warped and block faulted homocline.

"Near the Lebanon Reservoirs, possible faults are associated with the gap in the north border diabase dike." This area lies immediately southwest of the dam as shown on the Geology Map.

The rock strata underlying the dam and reservoir is the Gettysburg Formation, a member of the Newark Group of Triassic age. The Newark Group is a thick sedimentary sequence composed of shales, sandstones, and conglomerates, intruded by thick sills and dikes of diabase. The Gettysburg Formation consists of red shales, quartose red sandstones, and quartz conglomerates.

Gray, G., Geyer, A.R., and McLaughlin, D.B., "Geology of the Richland Quadrangle," Atlas 167D, Pennsylvania Geological Survey, Fourth Series, 1958.

LEGEND

TRIASSIC

diabase — Medium coarse grained, dark gray, composed chiefly of gray plagioclase feldspar and black or green augite.

GETTYSBURG FM.

conglomerate — Interbedded "shale conglomerate," coarse cobble conglomerate and red sandstone.

sandstone — Fine to coarse, red and brown, quartzose sandstone with a few red shale interbeds.

limestone + shale conglomerate — Fine to coarse, red and brown, quartzose sandstone with thin bands of quartz pebble conglomerate.

CAMBRIAN

Buffalo Springs Member — Light to pinkish gray limestone, cryptozoon beds near top, sandy in part, fine to coarse crystalline, interbedded dolomite, laminated in part.

SCALE

0 1/2 1 MILE

References:
Geologic atlas of Pennsylvania.
Geology of the Richland Quadrangle,
Pennsylvania Geological Survey,
Fourth Series, Atlas 167 D, 1958.

GEOLOGY MAP

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